KTC-93-31

DEVELOPMENT OF GUIDELINES AND PERFORMANCE FOR ASPHALT CONCRETE CONTAINING RECYCLED RUBBER

by

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in cooperation with
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and

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Mr. Kenny Fogle
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Frankfort, KY 40622

Subject: Research Report KTC 93-31
"Development of Guidelines and Performance for Asphaltic Pavements Containing Recycled Rubber"
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Dear Mr. Fogle:

The subject report is being submitted for review by the Study Advisory Committee. Please forward this report to the Chairman of the Committee, Mr. Willie McCann.

Please do not hesitate to call me if you have any questions.

Sincerely,

Calvin G. Grayson
Director

Attachments

km

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16. Abstract:

The primary objective of this study was to investigate the feasibility of implementation of the crumb rubber technology in Kentucky. The impetus for this study was provided by the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA).

This study included an overview of existing literature on the subject from an implementation point of view for Kentucky's conditions. Upon completion of this phase of the study, guidelines were developed by the KTC research team and were submitted to the Transportation Cabinet for field implementation of the crumb rubber modifier (CRM) technology in Kentucky. From the ease of implementation point of view, the Cabinet opted to build a field trial section using the "wet process" which utilized a fine ground rubber (80 mesh) material. The rationale for this decision was based upon the fact that the fine ground CRM mix closely resembles the polymer modified HMA, and that both the Cabinet and Kentucky contractors have an extensive amount of experience with polymer modified asphalt.

In July 1993, a field trial project was constructed on a portion of the US 421, Franklin County, Kentucky. The project involved milling of nominally one inch of the wearing surface followed up by a nominally one-inch overlay. The four-lane trial project (two lanes in each direction) was divided into two approximately half-mile sections. This allowed for a comparison of performance between the CRM hot mix asphalt (HMA) and the conventional HMA.

In summary, the trial implementation of the CRM technology in Kentucky proved to be a success. The 80-mesh fine ground rubber at 7.5% by weight of asphalt cement provided a material similar to polymer modified asphalt. Construction of the field project was possible with existing specifications and practices in Kentucky. The non-intrusive nature of the fine ground technology was most desirable from the ease of implementation point of view.

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EXECUTIVE SUMMARY

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This study included an overview of existing literature on the subject from an implementation point of view for Kentucky's conditions. Upon completion of this phase of the study, guidelines were developed by the KTC research team and were submitted to the Transportation Cabinet for field implementation of the crumb rubber modifier (CRM) technology in Kentucky. From the ease of implementation point of view, the Cabinet opted to build a field trial section using the "wet process" which utilized a fine ground rubber (80-mesh) material. The rationale for this decision was based upon the fact that the fine ground CRM mix resembles closely the polymer modified HMA, and that both the Cabinet and Kentucky contractors have an extensive amount of experience with polymer modified asphalt.

In July 1993, a field trial project was constructed on a portion of the US 421, Franklin County, Kentucky. The project involved milling of nominally one inch of the wearing surface followed up by a nominally one-inch overlay. The four-lane trial project (two lanes in each direction) was divided into two approximately half-mile sections. This allowed for a comparison of performance between the CRM hot mix asphalt (HMA) and the conventional HMA.

The mix design was developed jointly by the contractor and the KTC research team. Construction of the trial section proceeded without any difficulty. A documentation of key features of construction activities is presented in this report. Post-construction interviews with the contractor reveled that the CRM hot mix construction was very similar to the conventional HMA construction.

In summary, the trial implementation of the CRM technology in Kentucky proved to be a success. The 80-mesh fine ground rubber at 7.5% by weight of total asphalt binder provided a material similar to polymer modified asphalt. Construction of the field project was possible with existing specifications and practices in Kentucky. The non-intrusive nature of the fine ground technology was most desirable from the ease of implementation point of view.

ACKNOWLEDGEMENTS

The authors of this report wish to acknowledge the financial support provided for this study through Kentucky Transportation Cabinet and U.S. Department of Transportation, Federal Highway Administration. Valuable comments offered by the Study Advisory Committee Chairman, Mr. Willie McCann are appreciated. The Kentucky Transportation Center (KTC) professional staff offered valuable assistance with various tasks of this study. In this regard, the authors would like to acknowledge the assistance offered by Messrs Daniel Eaton, John Fleckenstein, Clark Graves, Jack Harison, Bobby Meade, Richard Reitenour, and Tim Scully. The following students offered valuable assistant with this project: Messrs Robert Bosley, Philip Creamer, Brian Higgins, and Phillip Massie.

SCOPE OF THE STUDY

The overall objective of this study was to develop guidelines for utilization of crumb rubber in asphaltic concrete pavements. These guidelines were intended to cover areas dealing with materials characterization, mixture design, construction process control, and overall quality assurance/quality control (QA/QC) issues. New and innovative approaches to crumb rubber utilization as well as the traditional hot mix asphalt applications were investigated. General assessments of the economic and environmental impacts of the ISTEA mandate were also made.

The research study was conducted in accordance with a multi-phase approach: review of state-of-the-practice, laboratory characterization of mixtures, construction of field trial sections, and performance evaluation.

Phase I of the research involved investigation of potential applications for recycled rubber and development of an experimental plan for an experimental field application.

I.1. Identify and study the feasibility of potential methods for utilizing recycled rubber in bituminous pavement mixtures.

I.2. Develop recommendations for utilization of rubber modified hot mix asphalt, and stress absorbing membrane interlayer (SAMI). Develop guidelines for design and construction of rubber modified hot mix asphalt with little or no modifications to the current design/construction practices in Kentucky.

I.3. Develop a plan for an experimental field application for the most promising potential utilization for recycled rubber in pavements.

Phase II of the research was designed to address the following long-term issues:

II.1. Evaluate performance of experimental sections in the field. Obviously, this will require funding commitment beyond the duration of this two-year study.

II.2. Develop guidelines for the long-term utilization of recycled rubber in pavements on the basis of the literature review and the experience with field studies in Kentucky. Again, this activity would require a continuation of efforts initiated during this study beyond the two-year duration of this study.

INTRODUCTION

U.S. motorists dispose of approximately 250 million automobile tires and about 25 million truck tires each year (SHRP 1991). Unofficial accounts indicate that in Kentucky we dispose of approximately 3.7 million tires per year which amounts to 1.7 tires/person/year. It is estimated that there are presently 40 million scrap tires in Kentucky, in one location alone (Alexandria, Kentucky) there is a pile of 10 million tires. Clearly, this poses a variety of environmental concerns, ranging from insect control, to air and water quality issues. All trends indicate that waste disposal is "out", and waste utilization is "in" (California Health Department, 1990).

The 1991 Intermodal Surface Transportation Efficiency Act (ISTEA) has mandated the use of scrap tire rubber in asphalt pavements on federal-aid funded projects in accordance with the following schedule:

a- 5 percent for the year 1994 (waived, section 325 of H.R. 275, 1993);
b- 10 percent for the year 1995;
c- 15 percent for the year 1996; and
d- 20 percent for the year 1997 and each year thereafter.

There are unique features related to the design and construction of asphaltic concrete pavements containing crumb rubber which deserve special considerations. These considerations often involve adaptation and/or modification of conventional asphalt technology to rubber-modified materials.

SUMMARY OF LITERATURE REVIEW

Task 1 (Review of the State-of-the-Practice) of the work plan included a survey of literature and submittal of an interim report. To this end, an interim report was submitted to the Cabinet in January 1993 (Report KTC-93-2). This report was intended to provide an overview of the literature on the subject. In 1992, an FHWA report was released on the subject; this report provides an excellent source of information on the history, as well as the state-of-the-art of the asphalt rubber technology (Heitzman 1992). In the context of this final report, the intention is to provide a summary of key points that are important to successful implementation of the asphalt rubber technology in Kentucky in accordance with ISTEA, while realizing that more details may be found in references listed at the end of this report. Various asphalt rubber technologies are presented in this report along with their advantages and disadvantages. Issues related to structural design and construction are also discussed. A variety of environmental issues such as: emissions, leachate and issues related to future recyclability are presented. Finally, criteria are recommended to be used for selection of future asphalt rubber projects in Kentucky.

Terminology

Unfortunately, the misuse of asphalt rubber terms is common throughout the asphalt industry. This section is designed to establish a common ground for the asphalt rubber terminology in Kentucky. Terminology that is acceptable by ASTM, FHWA, and asphalt rubber producers is summarized and it is recommended for adoption by the Transportation Cabinet. The following summary of terminology and abbreviations was adopted from the report FHWA-SA-92-022 by Heitzman, 1992.

Asphalt Rubber (AR):
: Asphalt cement modified with crumb rubber. Note that ASTM D-8 defines it as: "a blend of asphalt cement, reclaimed tire rubber and certain additives in which the rubber component is at least 15% by weight of the total blend and has reacted in the hot asphalt cement sufficiently to cause swelling of the rubber particles".

Buffing Waste:
: High quality scrap tire rubber which is a by-product from the conditioning of tire carcasses in preparation for retreading.

Crackermill:
: Process that tears apart scrap tire rubber by passing the material between rotating corrugated steel drums, reducing the size of the rubber to a crumb particle (generally 4.75 millimeter to 425 micron, No.4 to No. 40 sieve).

Crumb Rubber Modifier (CRM):
: A general term for scrap tire rubber that is reduced in size and is used as a modifier in asphalt paving materials.

Cryogenic:
Process that freezes the scrap tire rubber and crushes the rubber to desired particle size.

Diluent:
A lighter petroleum product (typically kerosene) added to asphalt rubber binder just before the binder is spray applied to the pavement surface.

Dry Process:
Any method that mixes the crumb rubber modifier with the aggregate before the mixture is charged with asphalt binder. This process only applies to hot mix asphalt (HMA) production.

Extender Oil:
An aromatic oil used to supplement the asphalt/crumb rubber modifier reaction.

Granulated CRM:
Cubical, uniformly shaped, cut crumb rubber particles having a low surface area which are generally produced by a granulator.

Granulator:
Process that shears apart the scrap tire rubber, cutting the rubber with revolving steel plates that pass at close tolerance, reducing the size of the rubber to a crumb particle (generally 9.5 millimeter to 2.0 millimeter, 3/8-inch to No. 10 sieve).

Ground CRM:
Irregularly shaped torn crumb rubber particles having a large surface area which are generally produced by a crackermill.

Micro-mill:
A process that further reduces a crumb rubber to a very fine ground particle, reducing the size of the crumb rubber below 425 micron (No. 40 sieve).

Reaction:
The interaction between asphalt cement and crumb rubber modifier when blended together. The reaction, more appropriately defined as polymer swell, is not a "chemical reaction". It is the absorption of aromatic oils from the asphalt cement into the polymer chains of the crumb rubber.

Rubber Aggregate:
Crumb rubber modifier added to HMA mixture using the dry process which retains its physical shape and rigidity.

Rubber Modified Hot Mix Asphalt (RUMAC):
Hot mix asphalt which incorporates crumb rubber modifier primarily as rubber aggregate.

Shredding:

Process that reduces scrap tires to pieces 0.15 meter (6 inches) square and smaller.

Stress Absorbing Membrane (SAM):

A surface treatment using an asphalt rubber spray and cover aggregate.

Stress Absorbing Membrane Interlayer (SAMI):

A membrane beneath an overlay designed to resist the stress/strain of reflective cracks and delay the propagation of the crack through the new overlay. The membrane is often a spray application of asphalt rubber and cover aggregate.

Wet Process:

Any method that blends crumb rubber modifier with the asphalt cement prior to incorporating the binder in the asphalt paving project.

NOTE:
According to the Asphalt-Rubber Producers Group (ARPG), the term Asphalt Rubber should be used when referring to the material derived from the wet process, while the term Rubberized Asphalt should be used for the material produced via the dry process (Roads and Bridges Magazine, December 1992).

Major Applications of the CRM Technology

Wet Process

This process is basically an asphalt binder modification process. The crumb rubber modifier (CRM) is added to the asphalt binder prior to its paving application. A reaction takes place between the asphalt and the CRM at high temperatures (350°F to 400°F) and after 45 minutes to 1 hour of mixing and agitation. This reaction, which is called polymer swell, is often enhanced by the addition of extender oils such as kerosene.

Advantages

1. Performance tends to be similar to polymer modified asphalts. That is, the crumb rubber modified asphalt produced via the wet process exhibits higher viscosity and less temperature susceptibility compared to the original unmodified asphalt.

2. Because the process deals with the binder alone, it lends itself to both hot mix and spray applications. It may also be produced in emulsion form (Terry Industries, 1992).

3. In hot mix applications, the material may be used in batch plants as well as drum plants without any operational complications.

4. Mix design may be accomplished with minor modifications to the conventional hot mix design practices. These modifications are almost identical to binder rich polymer modified mixes.

5. Experienced suppliers operate under the umbrella of the Asphalt-Rubber Producers Group (ARPG, sometimes referred to as the "Arizona Group"). These suppliers have the experience and the capability of engaging in a partnering relationship with the state DOTs and producing a custom made product.

Disadvantages

1. The crumb rubber modified binder produced via the wet process has a short shelf life; it must be used within hours of its production.

2. Special pumps and tanks (reaction tanks with a mechanical agitator system) are needed.

3. Frequent monitoring of the reaction is necessary.

4. Long-term performance characteristics are unknown.

Dry Process

The term "dry" refers to the addition of granulated crumb rubber to the heated aggregate in dry form prior to becoming "wet" by asphalt. Due to the particular nature of this process, there is only a slight reaction between the granulated rubber and asphalt cement during mixing.

Advantages

1. Application in the batch plant is simple. Bags of CRM may be delivered to the pugmill similar to certain polymers, fibers, etc.

2. Compared to the wet process, much larger quantities of scrap tire rubber may be disposed of in this manner.

3. The production cost of granulated rubber is less than the fine ground type. Additionally, the dry process HMA is less complicated and therefore, less expensive than the wet process. Hence, the overall cost of dry process is less than the wet process (dry process: 30% to 50% cost increase, compared to wet process: 60% to 100%, Roads and Bridges Magazine, December 1992; Rouse Rubber Industries, Information Brochures, 1992; Estakhri et al., 1992; Heitzman, 1992).

4. In response to a patented gap graded dry process, called PlusRide, most states have developed their own versions, called generic dry technology, information on which is available to the public.

Disadvantages

1. The dry process is only limited to HMA applications.

2. It is hypothesized that with time, the "unreacted" rubber particles in the asphalt pavement rob the asphalt from its lighter molecules and thereby induce premature aging and brittleness in the pavement.

3. Application in the drum plant involves introducing the CRM at a point away from the flame in order to prevent emissions associated with combustion of rubber (i.e. blue smoke). This requires a drum plant having an opening designed for this purpose (such as the recycled asphalt opening) or double barrel drum plant. However, this may not be a major concern since most drum plants in Kentucky are outfitted with a recycled material feed capability.

4. Depending upon the size of rubber particles used, alterations in the aggregate gradations and the job-mix formula may be necessary.

5. Long-term performance characteristics are unknown.

New Technologies

UltraFine™

Rouse Industries, of Vicksburg, Mississippi, developed a material which is very fine 180 micron (No. 80 mesh) - with a mean particle size of 74 micron (No. 200 mesh), Rouse Rubber Industries, Information Brochures, (1992). They have shown that by using their UltraFine™ material the "reaction time" may be significantly reduced (less than a minute instead of an hour). There have been a few test sections in place and data on long-term performance of this material are not available.

Advantages

1. Short reaction time.

2. Has potential to be produced at the terminal in a manner similar to conventional modified asphalt binders.

Disadvantages

1. The material producer has been primarily focusing on selling the UltraFine™ material and not necessarily the associated paving technologies.

2. Long-term performance characteristics are unknown.

Flexochape™

The French road contractor, Beugnet, developed a process by which the shelf life of the asphalt rubber increases to eight days; the binder is marketed under the trade name Flexochape™. Conventional asphalt rubber binders, produced by the wet process, must be used within a few hours of production. The Flexochape™ may viewed as a major breakthrough in implementation of asphalt rubber technology. At this time, there are no performance data available for this material.

Advantages

1. Extended shelf life (days instead of hours).

2. Has a long-term potential to be handled in a manner similar to conventional modified asphalts.

Disadvantages

1. It is expected to be very expensive.

2. It is not widely available in the U.S.

3. Long-term performance characteristics are unknown.

Chunk Rubber Asphalt Concrete

The Cold Regions Research and Engineering Laboratory (CRREL) of the U.S. Army Corps of Engineers was contracted by the Strategic Highway Research Program (SHRP) to study ice-debonding characteristics of paving materials. Initially, PlusRide was marketed as a very flexible asphalt having ice-debonding properties. As an extension of the PlusRide concept, CRREL developed a dense graded mix having a CRM gradation within 12.5 to 4.75 millimeter (1/2-inch to No. 4 sieve). Unfortunately, studies on this material have been limited to the laboratory only.

Other Applications

Surface Treatments

A surface treatment that involves a spray application of asphalt rubber followed by a layer of cover stone is called a stress absorbing membrane (SAM). Surface treatment is a very inexpensive means of providing a fresh pavement surface with good skid resistance. Sometimes, the membrane is sandwiched between two layers of a pavement structure, in which case the membrane is called a stress absorbing membrane interlayer (SAMI). Perhaps the most widespread application of SAMI is as a reflective crack retarder in asphalt overlays on top of aged portland cement concrete pavements.

Asphalt rubber SAM or SAMI may be applied with minor modifications by use of conventional surface treatment equipment. However, these modifications are necessary to account for the harshness of the CRM asphalt binder and its excessive wear on the equipment and higher operating temperatures.

Finally, there are other uses for surface treatments and spray applications which include: tack coat, fog seal, cape seal, microsurfacing, and many others.

Advantages

1. Ease of application.
2. Low cost.

Disadvantages

1. It adds no structural benefit to the pavement.
2. Heavy-duty spray nozzles and pumps are required.
3. Relatively small amount of rubber is disposed in this fashion.
4. Long-term performance characteristics are unknown.

Joint and Crack Sealants

Perhaps the most unadvertised use of rubber in asphalt is in the form of products that are used for joint and crack sealing. The process for producing this materials is identical to the wet process for asphalt rubber with a typical rubber content of approximately 18%.

Advantages

1. Ease of application.

2. Low cost.

Disadvantage

1. Relatively small amount of rubber is disposed in this fashion.

2. Long-term performance characteristics are unknown.

Structural Design Issues

There is a tendency to assign a higher structural coefficient to crumb rubber modified asphalt primarily on the basis of its higher stiffness/modulus as compared to conventional hot mix asphalt. Based upon studies in California and Arizona, Van Kirk (1992) concluded that CRM asphalt overlays may be designed 30%-50% thinner than the conventional HMA overlays having the same performance. It must be pointed out that Van Kirk's report reflects a limited database and the author cautions against unwarranted extrapolations.

As a result of lack of adequate information on structural behavior of CRM asphalt, state agencies are considering construction applications which would minimize exposure to traffic loads. This has led to applications in shoulders, base, and/or subbase courses. Base and subbase applications offer an added advantage of isolation from most environmental elements leading to a more durable pavement.

Construction Issues

Plant Type

The asphalt rubber technology lends itself to both spray and hot mix applications. At the same time, in the wet process and spray applications, the harsh and viscous nature of the CRM asphalt binder requires heavy duty pumps and nozzles. Both dry and wet processes may be accomplished with the currently available plant technology in Kentucky. The drum plant, however, must have an opening, away from the flame, for introduction of rubber particles. This may be easily accomplished through the opening for the recycled asphalt pavement (RAP) materials, which most drum plants in Kentucky presently have. Batch plants, on the other hand, offer a means for easier application and better quality control.

Compaction

Compaction of CRM hot mix asphalt (CRM-HMA) may be easily accomplished with conventional equipment. Some minor increase in the level of field compaction might be necessary due to the more viscus nature of CRM asphalt binder, which makes the mix somewhat harsh. Some rubber mixes containing coarse rubber particles have a tendency to exhibit "elastic rebound", which may make achieving the specified field densities more difficult.

Post Compaction Cooling Prior to Exposure to Traffic

Rubber is known to increase the latent heat capacity of hot mix asphalt. Therefore, it might be necessary to provide a longer cooling time for the freshly laid asphalt pavement prior to exposure to traffic.

DESCRIPTION OF THE FIELD TRIAL PROJECT

A field project was identified for evaluation of various aspects of CRM-HMA in relation to construction and performance. The construction consisted of a series of control and modified asphalt sections on a segment of the US 421, in Franklin County, Kentucky, as depicted in Figure 1.

Field trial sections were constructed during July 1993. A nominal 1-inch surface layer was applied to both CRM-HMA and control HMA sections. The primary purpose of a surface course is to protect the structural layers from environmental effects. A 1-inch surface layer was neither intended nor provides any structural support. This field project, however, was selected for evaluation of feasibility and performance of CRM in Kentucky using the fine ground rubber material.

PAVEMENT CONDITION SURVEY

Visual Inspection of US 421

On June 29, 1993, Kentucky Transportation personnel conducted a visual condition inspection of the pavement surface on US 421 prior to the milling and overlay operations. Transverse, longitudinal, and map cracking was observed in several areas throughout the project. Pumping and bleeding were also observed in several locations. Rut measurements were taken every 0.1 mile. The average rut depth was 0.32 inch. The maximum rut depth recorded was 0.8 inch at Milepost 3.8, northbound, at the intersection of US 421 and Schenkel Lane. The pavement had been overlaid from Milepost 3.0 to 3.25, and from Milepost 3.8 to Milepost 4.2. Changes in pavement structure such as overlays were indicated on the condition sheets as pavement visual appearance change. The condition information is contained in Tables 1 and 2, and Appendix A.

Video and Infrared Documentation of US 421

On July 1, 1993, Kentucky Transportation Center personnel videotaped the pavement surface prior to being overlaid with the CRM-HMA and control HMA surfaces. The video tapes and their associated distress survey sheets will be used to monitor reflective cracking in the rubberized asphalt overlay. In addition to videotaping the surface, KTC personnel also used thermography equipment (infrared scanner) to scan the pavement surface for any large irregularities in surface temperature. This was the first attempt to use this equipment for this application in Kentucky. The results appear to be promising.

The thermography equipment revealed several cool areas throughout the study area. Most of the cool areas detected were associated with areas of significant pavement distress (map cracking or staining due to pumping). It is apparent the pavement was cooler in these areas probably due to water being trapped in the pavement and subgrade. At milepost 4.27, significantly cooler pavement temperatures were observed between the two northbound lanes. The surface was severely cracked in several regions in this area (Figure 2).

At milepost 4.18, a cool area was detected in the center of the southbound driving lane (Figure 3). No surface distress was apparent on the pavement surface. At milepost 4.15, at the adjacent "on" ramp, significant cracking and pumping was were observed.

Several hot spots were detected during the infrared survey. Hot spots were detected at milepost 3.34 in the center of the northbound driving lane, and at milepost 3.27 in the center of the southbound driving lane (Figure 4). No surface distress was observed at either location. Background literature indicates that these hot spots could be delaminations between layers.

NONDESTRUCTIVE PAVEMENT TESTING

Nondestructive deflection testing was conducted using a JILS-20 Falling Weight Deflectometer. Deflections were measured using a 12-inch diameter loading plate and a dynamic load of 9,000 lbs. Deflections were measured at seven locations spaced at 12-inch centers from the center of the load plate.

Asphaltic concrete cores were obtained at four locations after overlay. These cores revealed considerable variability in both the asphaltic concrete and dense graded aggregate thicknesses. These thickness measurements are summarized in Table 3.

Backcalculation of Layer Moduli

Falling Weight Deflectometer deflection measurements were obtained prior to the milling operation in July 1993. Deflection measurement were also obtained in October 1993 after placement of the asphaltic concrete overlay. Deflection measurements were obtained at 0.1-mile increments. Layer moduli were backcalculated for each set of deflection measurements using Modulus Version 4.0. The backcalculated asphaltic concrete modulus was converted to an equivalent modulus at 70 degrees Fahrenheit using a relationship reported in KTC Research Report KTC-92-10.

Due to the large variation of material thicknesses given in Table 3. Two different backcalculation scenarios were utilized. The first scenario was to use an average material thickness as determined from the field cores. These thicknesses were used as inputs into the MODULUS computer program and layer moduli were calculated. The average layer moduli for each layer in each direction for both sets of FWD measurements is given in Table 4 the actual test temperature is given in parentheses.

It may be seen from Table 4. that there is a slight increase in asphaltic concrete modulus once the overlay was placed. However, the backcalculated asphaltic concrete layer moduli seem higher than might be expected. This may be due to asphaltic concrete age. The pavement structure is approximately 20 years, therefore it is possible that the material may have become brittle and age hardened. Due to the thin overlay thickness, it is not possible to backcalculate a modulus for the overlay itself. Hence, a modulus was calculated for a composite asphalt layer (surface plus base). Tabular and graphical summaries for the backcalculation are given in Appendix A.

The second scenario involved backcalculating layer moduli on a site specific basis where the asphaltic cores were obtained. Layer moduli were backcalculated for each site at the two sites adjacent to it. The results of this analysis are given in Table 5.

It may be seen from Table 5 that at two locations the asphaltic concrete modulus increased after overlay, while in the remaining three locations the asphaltic concrete modulus slightly decreased or remained nearly the same. The detailed backcalculation results for this analysis are given in Appendix A.

General Comments about the FWD Analysis

It may be seen from the figures in Appendix A that considerable variability in the backcalculated layer moduli is observed across the project. A portion of this variability may be due to the variation of the material thicknesses across the project. Similar trends in this variability are observed in both the July and October data. The changes in the average backcalculated DGA and subgrade moduli may be attributed to changes in their moisture content from July to October. This analysis will provide a good baseline of material information for future evaluations.

SUMMARY OF CONSTRUCTION ACTIVITIES

From the ease of implementation point of view, the Cabinet opted to build a field trial section using the "wet process" which utilized a fine ground rubber (80-mesh) material. The rationale for this decision was based upon the fact that the fine ground CRM mix resembles closely the polymer modified HMA, and that both the Cabinet and Kentucky contractors have an extensive amount of experience with polymer modified asphalt.

In July 1993, a field trial project was constructed on a portion of the US 421, Franklin County, Kentucky. The project involved milling of nominally one inch of the wearing surface followed up by a nominally one-inch overlay. The four-lane trial project (two lanes in each direction) was divided into two approximately half-mile sections. This allowed for a comparison of performance between the CRM hot mix asphalt (HMA) and the conventional HMA.

The following is a summary of key features of the construction activities. The contractor was H.G. Mays of Frankfort, Kentucky.

- The fine ground rubber (80-mesh, Rouse) was mixed with the AC-20 binder at 7.5% rate by the weight of the total binder. The rubber was fed via an auger system into a blending unit where it was mixed with the hot AC-20. The auger speed may be adjusted to produce any rubber content in the asphalt.

- The contractor used an asphalt transport unit as a temporary delivery facility feeding hot AC-20 into the CRM blending unit. The temperature of the CRM blending unit was 340°F-350°F.

- The contractor used a drum plant at a production rate of 175-200 tons/hour, depending upon the progression of the job.

- At the beginning of the job, two 500-foot test strips were constructed to check the in-place properties. Two test strips were constructed to accommodate the change in the CRM binder content (from 5.3% to 5.1%). Each test strip was constructed with approximately 500-600 tons of HMA. The conventional HMA also included a test strip.

- The contractor used conventional laydown equipment. The paver machine was a model 561 Cedar Rapids. The paver had a 10-foot screed plus 2-foot extensions. Also, a 40-foot ski rode on the mat for level control purposes.

- The breakdown roll of the 1-inch surface lift was accomplished by a DD-110 Ingersoll-Rand (10-12 tons) steel drum roller, operating in the vibratory mode moving toward the paver and in the static mode moving away from the paver. The compaction was finished using a DA-40 Ingersoll-Rand (8-10 tons).

- Desirable field densities (92% to 94%) were accomplished in accordance with the following rolling pattern:

  1 vibratory pass and 3 flat passes (10-12 ton roller);
  4 flat passes (8-10 ton roller).

- There were few "fat spots" along the CRM-HMA sections. Although no conclusive cause has been determined, these spots correspond to locations where the paver was approaching a stop.

- The entire project included 2,563.13 tons of class AK surface HMA for control sections, and 3,198.79 tons of class AK surface CRM-HMA. The entire project was paved in six days.

- The cost of conventional HMA on this project was $29.60 per ton, while the CRM-HMA cost was $46.26 per ton.

POST-CONSTRUCTION INTERVIEWS

On July 21, 1993, a post-construction interview was held with the contractor. The following is a summary of key comments made during that meeting.

- The contractor indicated that the various people in charge of production and laydown would not have known the difference between the control Class AK and the CRM Class AK if they were not told. This is a positive sign that the CRM-HMA material selected for this project behaved similar to conventional HMA.

- As a result of CRM binder over-production, approximately 1500 gallons of CRM-AC-20 was left in the hot storage tank of the contractor overnight. In order to prevent any phase separation, the contractor recirculated the hot binder for the duration of that night. There were no problems associated with using this binder for mix production the following day.

- The contractor felt that overall QA/QC was improved because of the partnering relationship between his company, the Transportation Cabinet, and the KTC research team.

- The contractor was concerned about some relatively low TSR values which were obtained for the CRM-HMA. He suggested that future research may focus on compatibility of various anti-stripping agents, including lime, with the CRM-HMA.

- No unusual wear on the plant equipment was observed. Plant modifications were very minor.

- Simple observations indicated no difference in human perception of CRM-HMA versus conventional HMA on this project. Visual inspections revealed no difference between the finished surfaces of CRM-HMA and that of conventional HMA.

- In summary, the construction was a success. The contractor felt comfortable implementing this technology with existing Kentucky specifications and practices.

MATERIALS CHARACTERIZATION

Binder Viscosity Data

Generally, the CRM-AC-20 asphalt binder showed an increase in the viscosity which was comparable to an AC-40. This "jump" in the asphalt binder grade is similar to polymer modified asphalts. Hence, this is the best indication that fine ground (80-mesh) CRM changes the viscosity characteristics of asphalt cement in a manner which is very similar to polymer asphalt modifiers. Details of viscosity data are given in Appendix B.

For quality assurance and quality control (QA/QC) purposes several samples of the CRM asphalt binder were collected at various time during the production of the hot mix. The viscosity of these samples are reported in chronological order in Appendix B.

Aggregate Data

The aggregate gradation was a typical Kentucky Class AK surface material with a nominal top size of 1/2 inch to 3/8 inch. The aggregate consisted of the following components: 42% Nugent No. 8, 23% Harrod Limestone Sand, 19% Nugent Natural Sand, and 16% Nugent Crushed Gravel Sand. Details of aggregate gradations and job-mix formula are presented in the Appendix.

Marshall Mix Design

Marshall stability and flow are standard parameters for the evaluation of rutting resistance of asphalt mixtures. This methodology is being increasingly criticized within many circles, including the Asphalt Aggregate Mixture Analysis System, NCHRP 338 (Von Quintus et. al. 1991) and Strategic Highway Research Program, SHRP (Sousa 1991) for its weak correlation to field performance.

Mix design for this project was jointly conducted by the contractor and the KTC research team. The contractor (H.G. Mays Corporation, Frankfort, Kentucky) reported an optimum binder content of 5.1%, by weight of the mix, for both conventional and CRM mixes. The Transportation Cabinet's Materials Central Laboratory and the KTC research team verified the 5.1% binder content for the conventional HMA. However, the KTC research team reported 5.3% optimum binder content for the CRM-HMA. However, based upon visual observations of the mix and quality control checks on plant produced mix during construction of the first 500-foot test strip, the binder content for the CRM-HMA was dropped back to 5.1%. Details on mix design information generated by various parties and quality control checks on plant mix material are given in Appendix B.

In summary, the 5.1% binder content was based upon 3%-4% voids based upon 75 blows Marshall design. This binder content led to an average voids in mineral aggregate (VMA) of 15.5%, and an average percent voids filled with asphalt (VFA) of 65%.

Finally, an inventory of all HMA compacted specimens along with the identification numbers which were used in this study are given in Appendix B.

Indirect Tensile Strength

Diametral indirect tensile strength (ASTM D4123) tests were conducted in order to determine the cracking susceptibility of different mixtures. These tests were conducted at room temperature (70°F) and loading rate of 2 inches per minute.

- Tensile strength characteristics of class AK-surface revealed that there was not a significant change due to addition of the crumb rubber. Average tensile strength for conventional HMA was 144.18 psi, as compared to 138.34 psi for the CRM-HMA. This information was used to develop the tensile strength ratio (TSR) for moisture susceptibility analysis.

Moisture Damage Susceptibility

Stripping is the cause of many premature failures in asphaltic pavements. An accelerated moisture damage test, commonly known as the Root-Tunnicliff Moisture Damage Susceptibility Test (Tunnicliff and Root 1984) was employed in this study in accordance with the procedures outlined in Kentucky Method 64-428-85. The test calls for measuring tensile strength before and after a moisture conditioning procedure which is patterned after the Lottman procedure (Lottman 1978). The tensile strength ratio, TSR, which is presented in Appendix B, represents a remaining strength factor. This ratio was determined by computing the ratio of each mixture's tensile strength after the moisture treatment to the tensile strength before the treatment.

- Moisture damage susceptibility analysis was conducted based upon tensile strength ratio (TSR). The TSR for conventional HMA was 87.26% as reported by the KTC research team, and 81% as reported by the contractor. The TSR for the CRM-HMA was 86.5% as reported by the KTC research team, and 71% as reported by the contractor. The discrepancies in the TSR data may be attributed to the nature of this test which often leads to variable outcomes.

- Generally, the contractor compacted the fresh plant-produced mix at approximately the same temperature as the mix exited the plant (i.e. 300 °F). On the other hand, the reheated plant-produced mix at the KTC laboratory was compacted at 265 °F, which is Kentucky's specified compaction temperature for Marshall specimens. For the purpose of the TSR specimens, higher temperatures during compaction by the contractor resulted in a lower number of blows to meet the target air voids of 7% +/-1%. This may have been another source of variation between the TSR results reported by the contractor and the KTC research team.

Resilient Modulus

In pavement technology, the resilient modulus has long been used in lieu of the modulus of elasticity (AASHTO 1986). Generally, higher moduli indicate greater structural capacity. A high modulus asphaltic layer adds to the structural capacity of the pavement by protecting the base, subbase, and subgrade layers from being overstressed, and therefore it will reduce the probability of premature structural failure. However, a high modulus also coincides with higher brittleness, and such material will crack prematurely in fatigue and/or low temperature cracking modes of distress (Yoder and Witczak 1975). The relationship between higher cracking life (both low temperature cracking and fatigue cracking) and lower modulus is reported by several researchers (Goodrich 1988, and McLean and Monismith 1974). Therefore, in addition to serving as a characterization tool for structural capacity of pavement, the resilient modulus offers insight into cracking performance potential of asphalt mixtures.

At this time, resilient modulus data are not fully ready to be published. It is anticipated that this information will be included in the final report.

FIELD PERFORMANCE DATA

The trial sections have been in service for less than a year. A comprehensive pavement performance analysis would require a long-term performance record. It is therefore recommended that monitoring of these experimental sections be continued on a semi-annual basis for the next five years. At this time, visual observations indicate that the experimental pavement sections have not yet demonstrated any major modes of pavement distress.

QA/QC ISSUES

The following are issues that need to ne considered in order to maintain a high level of quality assurance and quality control throughout the CRM projects.

- Construction of a valid control section is a must.

- Routine collection of binder and mixture specimens for testing at least twice a day.

- Independent materials testing by the contractor, the Transportation Cabinet, and perhaps a third party is essential to remove any potential biases.

- The metering system for addition of CRM to asphalt cement is the only direct way by which the quantity of CRM added can be controlled. Indirect checks may be conduced through the viscosity of the CRM-binder.

- The parameters that proved to be effective in determining the quality of the CRM material produced were: binder viscosity, mixture density and voids, mixture strength characteristics (Stability, Flow, TSR), and in place density. It is also very important to adhere to the prescribed temperatures during the following activities: CRM blending with the AC, mixture production, and mixture laydown and compaction.

- In-place HMA properties must be checked through construction of at least one 500-foot test strip. If changes occur in the production of the mix at the plant, a new test strip may be warranted.

- The partnership relationship between the contractor, the Cabinet, and KTC, proved to be a success on this project and it is recommended for future CRM projects.

ENVIRONMENTAL ISSUES

In compliance with the Section 1038(b) of the 1991 ISTEA, the U.S. Department of Transportation and the Environmental Protection Agency submitted a report in June 1993 addressing environmental and performance issues related to the use of CRM in HMA pavements (DOT-EPA Report, June 1993). The following sections are direct excerpts of the DOT-EPA report.

Excerpts From U.S. DOT - EPA Report (pages 26-27)

A. Health/Environmental Assessment

The weight-of-evidence from the currently available information shows that the emissions from any asphalt plant, either producing conventional HMA or CRM HMA, can vary widely, both in the profile or emissions observed and in the levels of each contaminant released. Based on the findings from seven projects in the United States and Canada, the currently available data collectively indicate that no obvious trends of significantly increased or decreased emissions can be attributed to the use of CRM in HMA pavement production.

The finding of MIBK (methyl isobutyl ketone) in CRM asphalt pavement mixtures in three out of seven studies may warrant further investigation. An evaluation of the most exposed human population, workers involved in the production and construction of asphalt pavements containing CRM, indicates no obvious basis for concern of increased risk to this population, based principally on an analysis of emission data.

In summary, using the currently available information, we find there is no compelling evidence that the use of asphalt pavement containing recycled rubber substantially increases the threat to human health or the environment as compared to the threats associated with conventional asphalt pavements. The findings are based on the limited available data from a few studies. These conclusions are subject to revisions as additional information is obtained and evaluated.

B. Recycling

Based on the results of two projects where asphalt pavements containing CRM were recycled, the available literature, and an evaluation of variability in plant configurations and operations, this technology appears to be constructible as a recycled pavement. To date, these two recycled pavements are performing comparably to existing hot mix asphalt pavement. However, sufficient information regarding long-term performance and economics is not available. These two project represent an extremely limited perspective of the variability of in-service pavement properties, environmental conditions, varying asphalt cements and mixtures, and asphalt plant configurations and operations. However, there is no reliable evidence that asphalt pavements containing recycled rubber cannot be recycled to substantially the same degree as conventional HMA pavements.

Additional evaluations are contemplated and will be required to develop further criteria for recycling CRM asphalt pavements. A national pooled-funds study has been initiated. Thirty-three states will participate with FHWA and EPA to further evaluate recycling CRM pavements. Requests for proposals for this pooled-fund research effort will be solicited this fiscal year (1993).

C. Performance

While pavements containing CRM have been constructed and have been in service for as many as 29 years in Arizona, California, and a few other states and based on an extensive review of available literature and project data, only limited information on engineering and economic performance is available. This is due to limited documentation, experimental evaluation, and a resulting incomplete data base upon which to complete long-term performance evaluations. While other states have conducted limited experimental research with CRM technologies, the performance of asphalt pavements containing recycled rubber has received only limited evaluations under varied climatic and use conditions.

In order to develop a reliable cost and economic evaluation of pavements containing CRM, comparable information must be developed on the construction of CRM asphalt paving projects of typical size rather then experimental applications. The performance to date on the CRM projects has been mixed, some experiencing early failure, others performing comparably to conventional asphalt pavements, and some CRM pavements have performed better than conventional mixes. Due to limited documentation, the exact cause of the premature distress in CRM pavements has not been established. However, when properly designed and constructed, there is no reliable evidence to show that pavements containing recycled rubber will not perform adequately as a paving material.

We will continue national research on CRM technologies to develop reliable engineering and economic criteria for the CRM pavements. Additionally, many states are conducting coordinated research to evaluate the effects of local conditions and materials. The results of these studies will be included in long-term performance evaluations.

Other Miscellaneous Issues

It appears that the jury will be out on various issues related to the utilization of scrap tire rubber in asphalt for some time. The following sections summarize various issues which might be of concern to the Transportation Cabinet officials.

Potential for leachate of CRM asphalt pavements is another concern. One may hypothesize that local conditions such as soil conditions, surface runoff chemistry, and other factors which influence the Ph of surface and ground water may influence the chemistry of the leachate. More data are expected to be generated by the EPA in this area.

There is a major concern for recycling potential of the asphalt pavements containing rubber. Currently, the Kentucky Transportation Cabinet does not use recycled asphalt pavement (RAP) in hot mix. Use of RAP materials by the Cabinet is almost exclusively limited to base and subbase construction. Local governmental agencies, however, use a significant amount of RAP in their hot mix projects. There is potential for state legislation to mandate more usage of RAP in a manner similar to California, where landfill disposal of milled pavement surfaces is prohibited and RAP usage is as high as 80% in hot mix recycling projects. Obviously, as more RAP containing rubber is incorporated into the hot mix, the concern for recyclability of the RAP material becomes greater. The limited experience in California, Arizona, and Canada reflects that the problem of "blue smoke" in hot mix plants may be overcome when the RAP material containing rubber is applied away from the flame. Generally, for hot recycling applications, the double barrel drum plant offers the best quality material with little or no adverse environmental impact (ASTEC 1992).

On another note, one should remember that scrap tire recycling in asphalt pavements is often advertised as a major landfill relief factor. However, realistic estimates of sound asphalt applications reveal that only a small portion of waste tires may be incorporated into hot mix asphalt. Additionally, most rubber vendors would like to use clean tires in their shredding and grinding operations, which eliminates the use of tires recovered from dump sites. As a result, it is becoming more obvious that other uses of scrap tires (such as: geocomposite, light weight fill, crash cushion, fuel source in power plants and cement plant, etc.) must be promoted if we are to make a significant change in the tire waste dilemma.

One major issue concerning the use of scrap tires is documentation of the sources of tires. This is primarily an accounting issue that vendors wishing to conduct business with the Transportation Cabinet must provide clear tire import-export equivalencies if the source of their rubber is outside Kentucky.

Finally, Transportation Cabinet officials are genuinely interested in engaging in a partnering relationship with contractors on a case by case basis. This offers a unique opportunity for successful implementation of the crumb rubber technology within the time constraints of the ISTEA mandate.

GUIDELINES FOR IMPLEMENTATION OF CRM TECHNOLOGY IN KENTUCKY

Performance

It is clear from the ISTEA mandate that the CRM asphalt must meet the performance requirements of the conventional HMA applications.

Ease of Implementation

Obviously, from the implementation point of view, Transportation Cabinet officials would prefer a technology which is least disruptive to current practices and costs. The fine ground rubber (80-mesh) technology proved to be easily implementable for Kentucky's conditions without a need for altering current HMA practices and/or specifications in Kentucky. This is particularly true at rubber content of 7.5%, by weight of total binder, which results in a material similar to polymer modified asphalt.

Potential for Being Cost Effective in the Long Term

Although the primary thrust behind the implementation of the CRM asphalt technology in Kentucky appears to be the ISTEA mandate, this should not diminish the focus on engineering and cost aspects of the technology. Hopefully, wider availability of the technology and its associated market competition will reduce the cost of this technology. At the same time, more experience with the CRM asphalt and its performance will allow cost and performance comparisons to be based on engineering principles.

FHWA Equation for CRM-HMA Quantity

$$R = U \times (10M + 150S)$$

R= The kilograms of recycled rubber required to satisfy the minimum utilization.
U = The required utilization percentage expressed as a decimal.
M = The total contract metric tons of Federal-aid Hot Mix awarded during the fiscal year.
S = The total contract metric tons of Federal-aid Hot Spray Applied Binder awarded during the fiscal year.

Environmental Impact

Coordination with environmental agencies is recommended. The cost of monitoring plant emissions could be as high as \$10,000 to \$50,000 per day. At this time, it appears advisable to consult the EPA officials before developing plans for monitoring asphalt plant emissions in Kentucky.

CONCLUSIONS AND RECOMMENDATIONS

Based upon information presented in this report, the following conclusions are made. These conclusions are based upon statistical analysis of laboratory and field data. However, conclusions based upon the field data may have been premature due to the short service time, less than one year, of the US 421, Franklin County, Kentucky project.

- Mixture design and analysis of the CRM-HMA using the fine ground rubber (80-mesh) was possible with the existing Kentucky specifications and practices.

- Construction of the CRM-HMA using the fine ground rubber (80-mesh) was possible with the existing Kentucky specifications and practices.

- As expected, cost of the CRM-HMA ($46.26/ton) was higher than the conventional HMA ($29.60/ton). At this point, it is not clear whether the additional cost of the CRM-HMA is justifiable from a performance point of view. For this purpose, long-term performance monitoring of all CRM projects in Kentucky is recommended.

- Long-term field performance data are needed for evaluation of the performance. It is recommended that funds be made available for semi-annual monitoring of performance of the field trial project for the period of five (5) years.

- The US 421, Franklin County, Kentucky, field trial project focused on the "wet process", and specifically fine ground rubber from ease of implementation point of view. However, other CRM technologies are recommended to be investigated for possible implementation in Kentucky, including SAMI technology, for which an interim implementation guideline is included in Appendix C of this report.

- The contractor expressed willingness to in implementing various CRM technologies for future projects.

- The partnership arrangement between the contractor, Transportation Cabinet, and the KTC research team proved to be a success. All parties genuinely cooperated toward a successful project.

TABLE 2. Summary of visual condition survey prior to milling of surface wearing course.

RUT MEASUREMENTS
SOUTHBOUND, US 421

MILE POINT	RIGHT WHEEL PATH INSIDE LANE	LEFT WHEEL PATH INSIDE LANE	CRACKING CONDITIONS	
			INSIDE LANE	OUTSIDE LANE
3.1			None	None
3.2	0.19"	0.25"		
3.3	0.44"	0.38"		
3.4	0.31"	0.25"	Mild Transverse And Longitudinal Cracking	Mild Transverse And Longitudinal Cracking
3.5	0.38"	0.25"		
3.6	0.63"	0.56"		
3.7	0.50"	0.50"		Significant Transverse Cracking
3.8	0.50"	0.56"		
3.9	0.19"	0.19"		Mild Transverse And Longitudinal Cracking
4.0	0.38"	0.38"		
4.1	0.19"	0.25"		
4.2	0.25"	0.31"		
4.3	0.19"	0.25"		
4.4	0.06"	0.25"		

TABLE 3. Asphaltic Core Thickness, US 421, Franklin County, Kentucky.

Mile Point	AC Thickness (in.)	DGA Thickness (in.)
3.30 SB	8.50	11.00
3.60 SB	7.25	10.25
4.00 SB	7.50	11.50
4.225 SB	8.25	14.00
4.40 SB	9.25	14.00

TABLE 4. Backcalculated Layer Moduli, US 421, Franklin County, Kentucky.

Test Date	Layer Moduli (ksi)			
	Asphaltic Concrete (Test Temp.)	Asphaltic Concrete (70°F)	DGA	Subgrade
July 1993 NB	665 (86°F)	964	62	21
October 1993 NB	1,311(74°F)	1,181	64	37
July 1993 SB	562 (107°F)	1,243	43	19
October 1993 SB	1,232 (74°F)	1,353	65	31

TABLE 5. Site Specific Backcalculated Layer Moduli, US 421, Franklin County, Kentucky.

Test Date	Layer Moduli (ksi)			
	Asphaltic Concrete (Test Temp.)	Asphaltic Concrete (Adjusted for 70°F)	DGA	Subgrade
MP 3.3: 8.5 inches AC, 11 inches DGA				
July 1993, NB	521(86°F)	695	39.3	15
October 1993, NB	934(74°F)	678	68	17
July 1993, SB	508(104°F)	1,127	43	17
October 1993, SB	1,075(74°F)	1,089	50	39
MP 3.6: 7.25 inches AC, 10.25 inches DGA				
July 1993, NB	794(86°F)	1,057	52	22
October 1993, NB	1,158(74°F)	911	63	22
July 1993, SB	620(104°F)	1,375	19	28
October 1993, SB	1,278(74°F)	1,292	33	22
MP 5.0: 7.5 inches AC, 11.5 inches DGA				
July 1993, NB	643(86°F)	820	84	17
October 1993, NB	1,500(74°F)	1,276	74	34
July 1993, SB	734(104°F)	1,529	34	31
October 1993, SB	1,478(74°F)	1,495	59	57
MP 4.225: 8.25 inches AC, 14 inches DGA				
July 1993, NB	629(86°F)	802	70	15
October 1993, NB	1,500(74°F)	1,536	53	43
July 1993, SB	589(104°F)	1,152	98	35
October 1993, SB	1,442(74°F)	1,556	56	36
MP 4.4: 9.25 inches AC, 14 inches DGA				
July 1993, NB	611(86°F)	780	97	39
October 1993, NB	1,293(74°F)	1,325	48	74
July 1993, SB	822(104°F)	1,606	108	38.5
October 1993, SB	1,500(74°F)	1,618	77	77

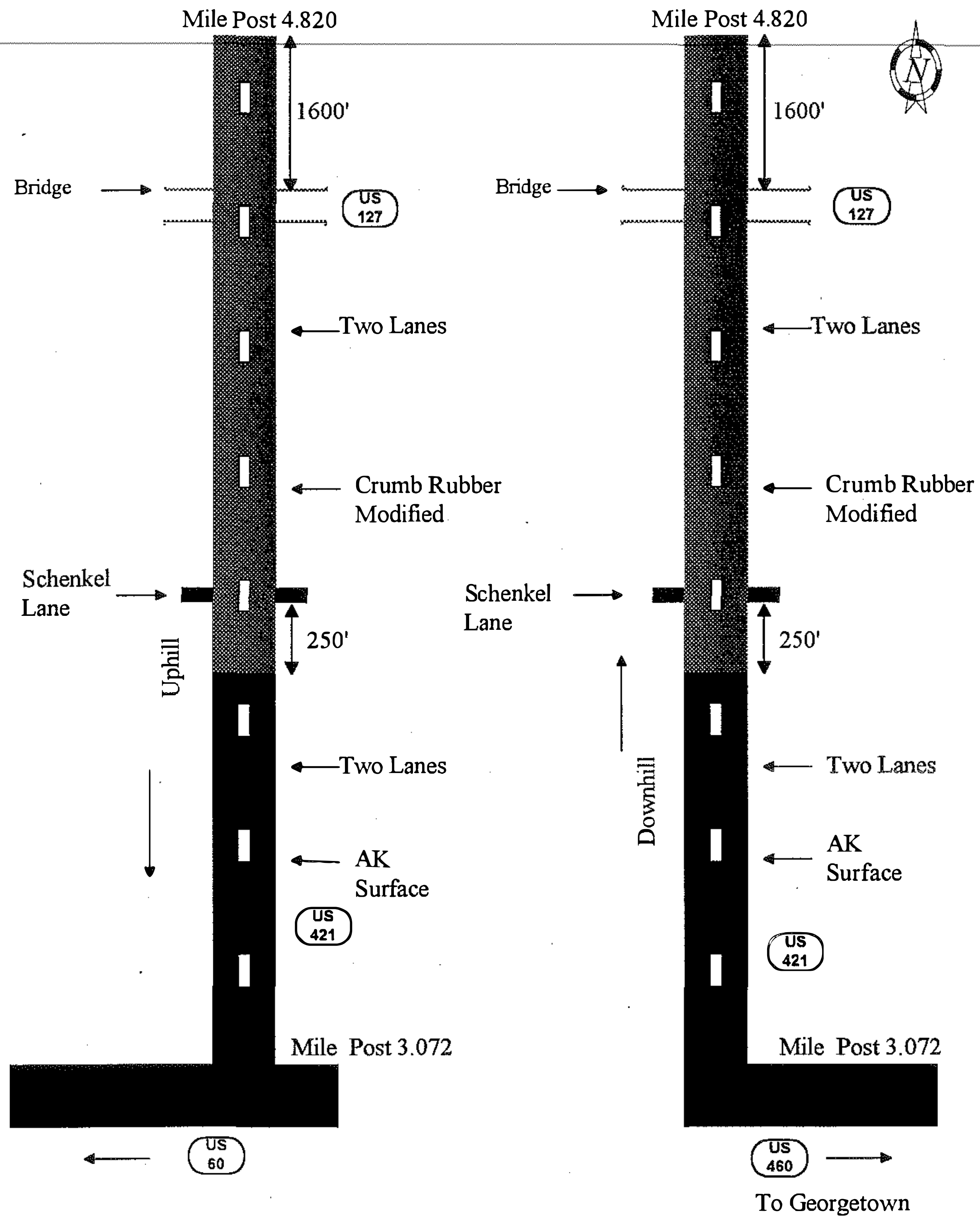

FIGURE 1. Project Layout, US 421, Franklin County, Kentucky.

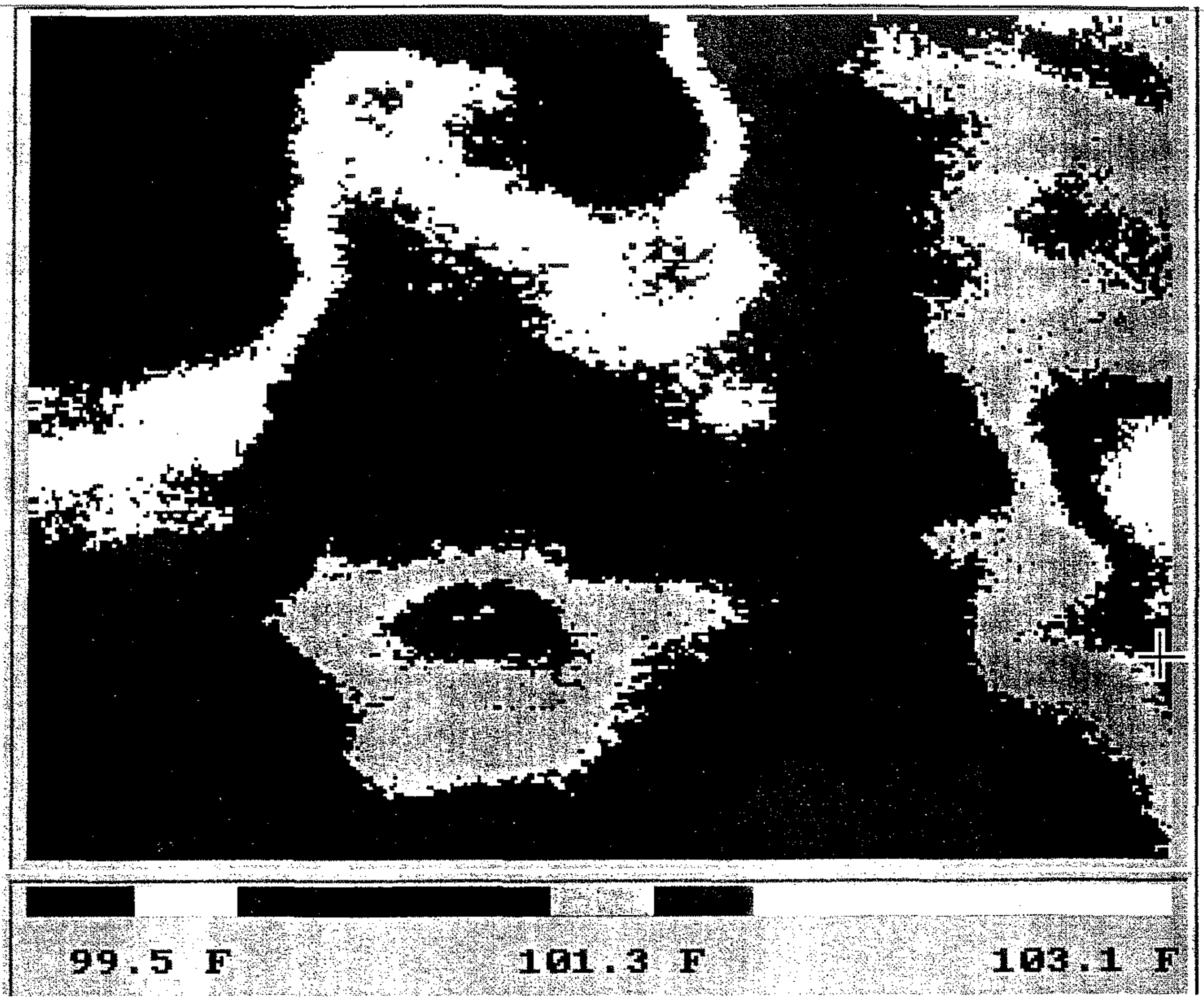

FIGURE 2. Infrared Image, MP 4.27-NB, US 421, Franklin County, Kentucky.

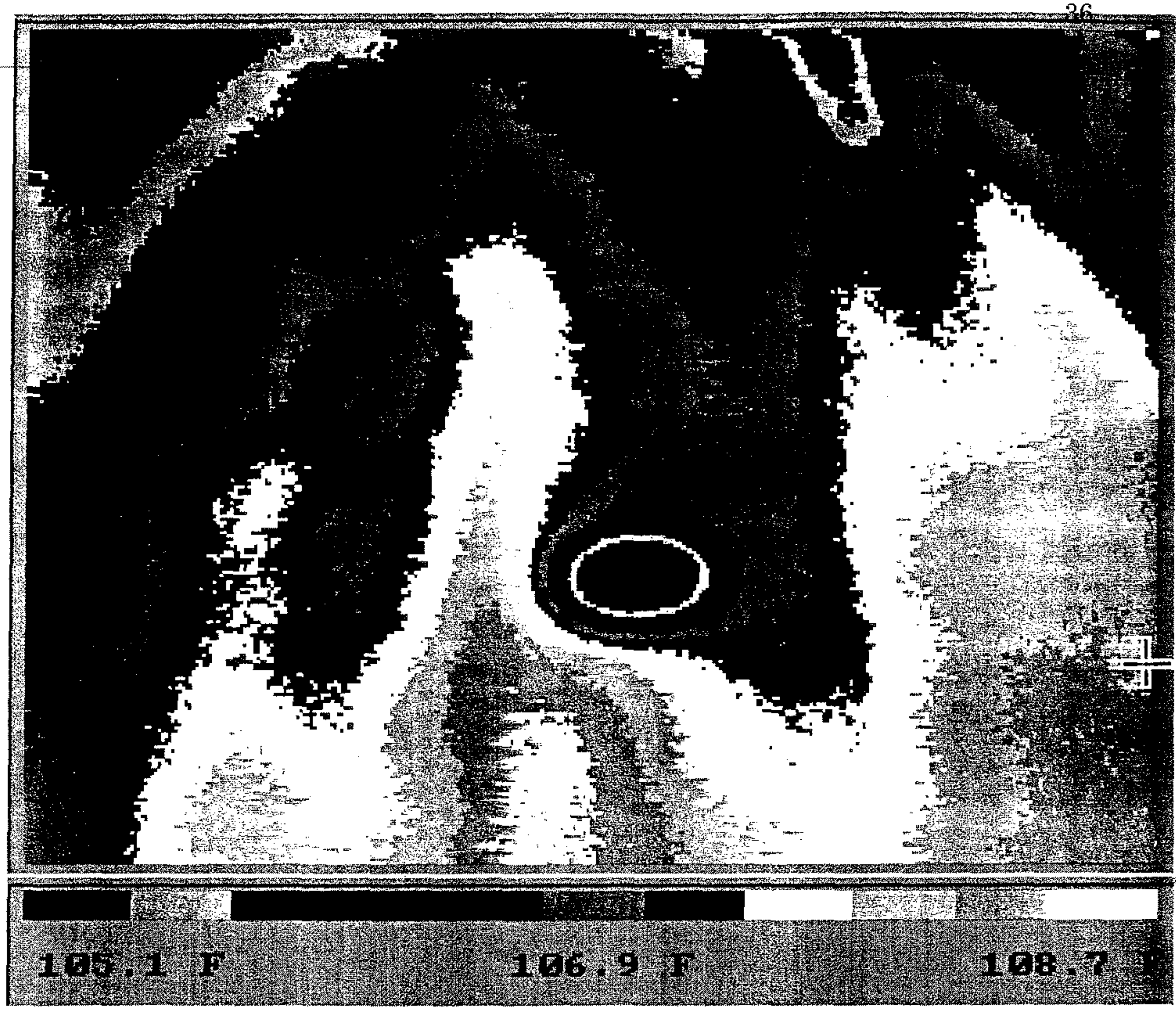

FIGURE 3. Infrared Image, MP 4.18-SB, US 421, Franklin County, Kentucky.

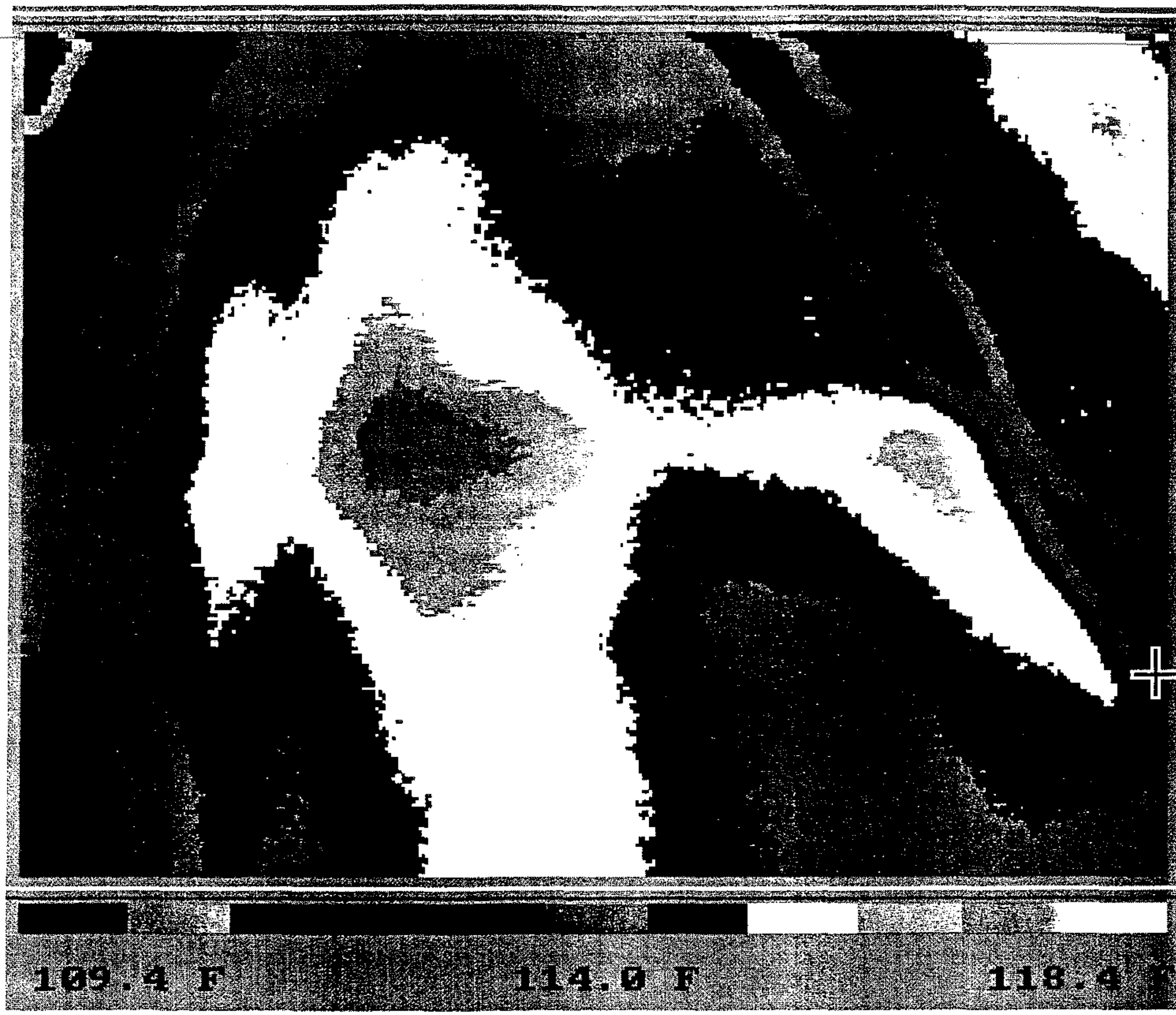

FIGURE 4. Infrared Image, MP 3.27-SB, US 421, Franklin County, Kentucky.

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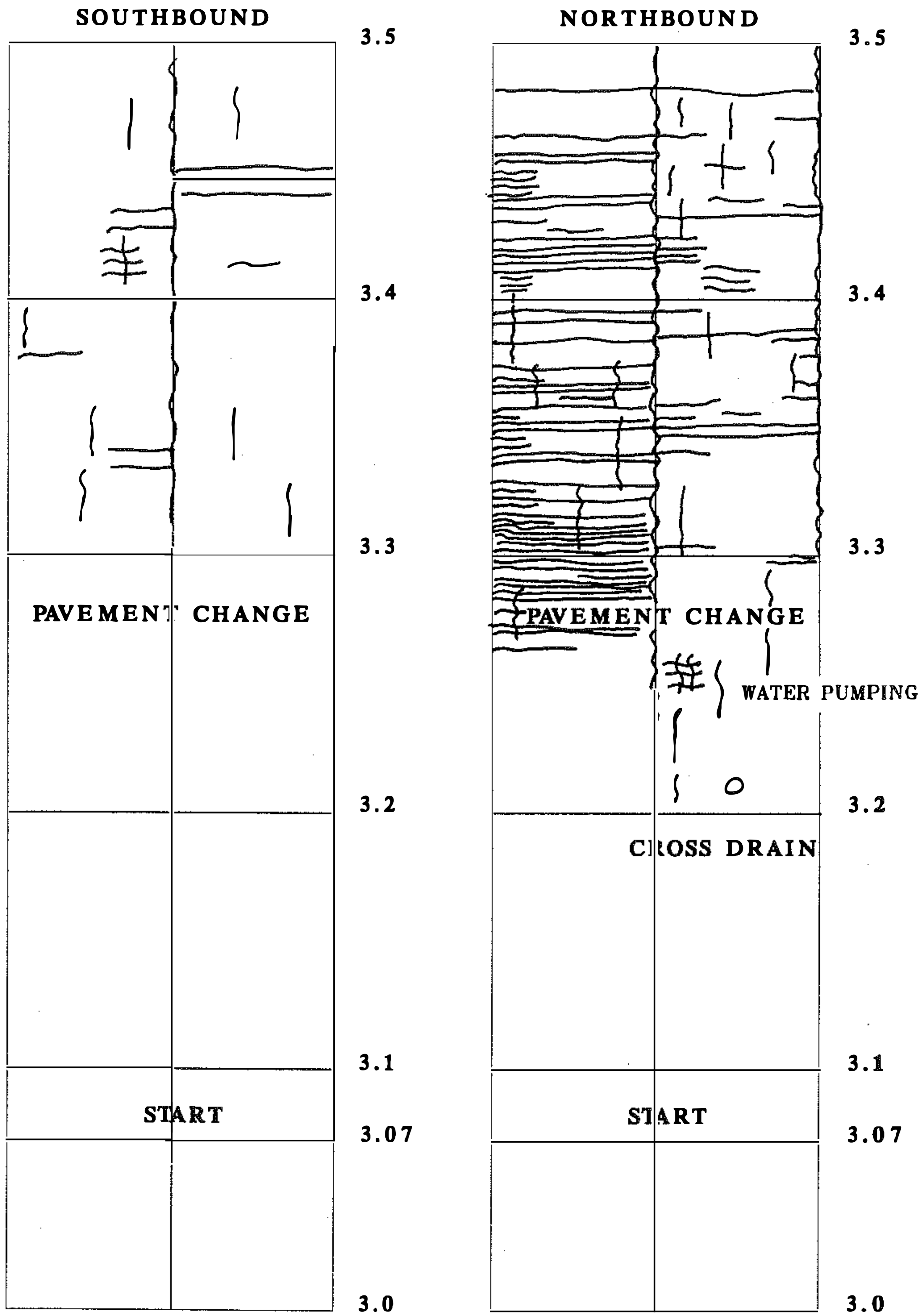
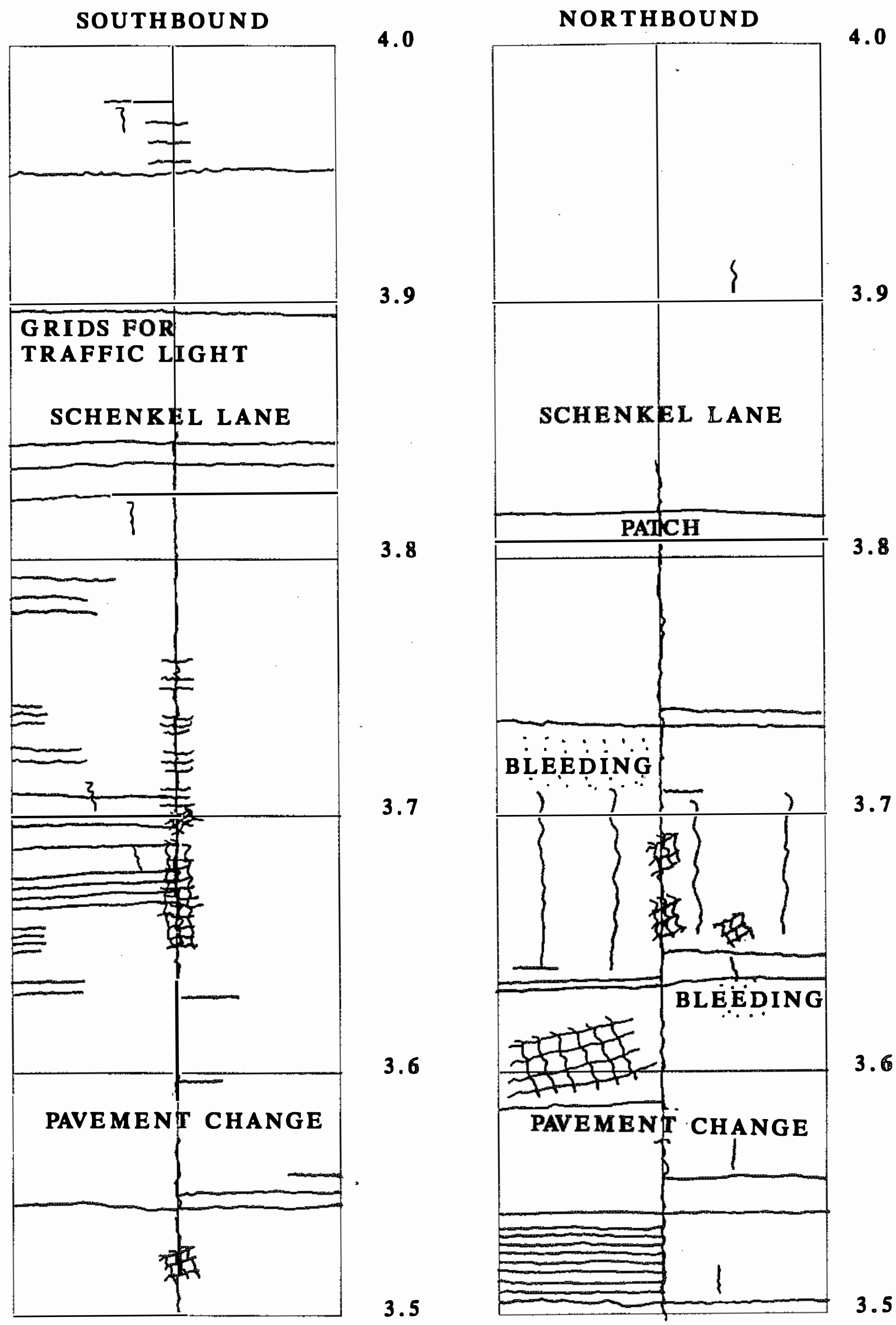
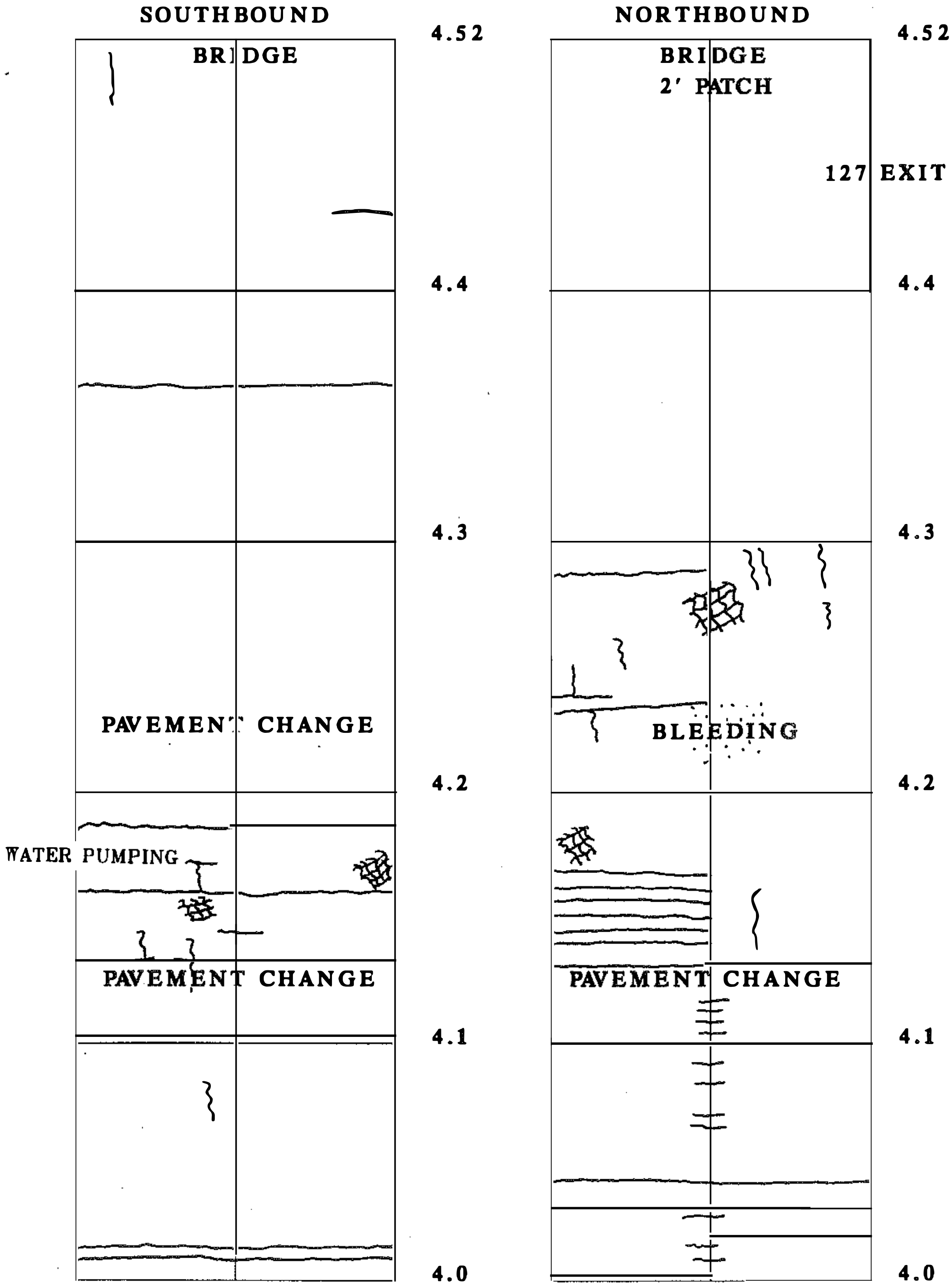
APPENDIX A - Pavement Condition Data

APPENDIX A1 - Visual Pavement Condition Survey Data



SOUTHBOUND
NORTHBOUND
3.5
3.4
3.3
3.2
3.1
3.07
3.0
PAVEMENT CHANGE
WATER PUMPING
CROSS DRAIN
START


SOUTHBOUND
NORTHBOUND
4.0
3.9
3.8
3.7
3.6
3.5
GRIDS FOR
TRAFFIC LIGHT
SCHENKEL LANE
PAVEMENT CHANGE
PATCH
BLEEDING


SOUTHBOUND
NORTHBOUND
4.52
BRIDGE
BRIDGE
2' PATCH
127 EXIT
4.4
4.3
PAVEMENT CHANGE
BLEEDING
4.2
WATER PUMPING
PAVEMENT CHANGE
PAVEMENT CHANGE
4.1
4.0

Transportation Cabinet
Department of Highways
Specialized Programs

TC 40-14
Rev. 2/91

Pavement Condition Evaluation Form

District: 1	County: FRANKLIN	Route No: US 421	Road Name: THORNHILL BY-PASS

From: (MP 3.072) US 60 To: (MP 4.820) 1600' N of US127 BE.

Length: 1.748	Width: 2 X 24'	Project No: MP-037-0421-003-005	System: SP

I. CONDITION SURVEY

	EXTENT: Few			Intermediate		Extensive		SEVERITY: Slight		Moderate		Severe	POINTS
Cracking	1	2	3	4	5	6		1	1.5	2	3	4	6
Base Failures (Faulting)		1	1.5	2	2.5	3	1.5	1	1.5	2	2.5	3	1.5
Raveling (Spalling)		.6	.9	1.3	1.6	2		.6	.9	1.3	1.6	2	3.2
Edge Failures		.6	.9	1.3	1.6	2	0	.3	.4	.6	.8	1	0
Out of Section		1	1.5	2	2.5	3		1	1.5	2	2.5	3	3
Appearance			Fair - 1.5, 2		Poor - 3, 4			Very Poor - 5					1.5
												Subtotal	15.2

				POINTS
II.	RIDEABILITY	N/E: 3.07 S/W: 3.02	RI 3.0	2.5
III.	RUTTING	N/E: S/W: up to 7/16"	Depth 3/8"	6
IV.	SKID RESISTANCE		SN No Points x Factor ___ x ___	—
V.	TRAFFIC VOLUME TRAVEL SPEED		AADT 19810 MPH 55	12 5

Raters: Dade, P.E. / McCann P.E
Date: 7/2/93

Total: 40.7
Points Ranking:

ROADWAY CHARACTERISTICS

PCC AC AC/PCC
Curbs & Gutters Manholes Inlet Boxes

Shoulders High ______ Low 1/2'
Width 10'
Type AC & Gravel

Industrial Haul Type ______
Patching (Percent) 3%

CO RECOMMENDATIONS

Improvement Needed? Yes Marginal No
Type: Resurface (AC) Other ______
Preparation: Leveling & Wedging (Percent) 20
Milling (in.) ______ Other Mill Parts of it
Other: ______

STATEWIDE RANKING:

DISTRICT RANKING:

Preparator: ______ DISTRICT RECOMMENDATIONS
Cost Estimate: ______
Treatment Code: ______
Remarks: ______

K.M.

Transportation Cabinet
Department of Highways
Specialized Programs

TC 40-1
Rev. 2/9

Pavement Condition Evaluation Form

91
16
D

District: 5	County: FRANKLIN	Route No: US 421	Road Name: THORNHILL BY-PASS

From: (MP 3.072) US 60 To: (MP 4.520) US 127 BRIDGE

Length: 1.448	Width: 2X24'	Project No: MP-037-0421-003-005	System: SP

I. CONDITION SURVEY

MP 3.072- 3.600 77
MP 3.600- 4.520 70

	EXTENT: Few		Intermediate		Extensive		SEVERITY: Slight		Moderate		Severe	POINTS
Cracking	1	2	3	4	5	6	1	1.5	2	3	4	6.0
Base Failures (Faulting)	1	1.5	2	2.5	3	1.5	1	1.5	2	2.5	3	1.5
Raveling (Spalling)	.6	.9	1.3	1.6	2		.6	.9	1.3	1.6	2	2.9
Edge Failures	.6	.9	1.3	1.6	2	0	.3	.4	.6	.8	1	0
Out of Section	1	1.5	2	2.5	3		1	1.5	2	2.5	3	3.0
Appearance		Fair - 1.5 / 2			Poor - 3 / 4			Very Poor - 5				1.5
											Subtotal	14.9

II. RIDEABILITY	N/E: 3.07 S/W: 3.14	RI 3.1	1.0
III. RUTTING	N/E: S/W: UP TO 7/16"	Depth 3/8	6.0
IV. SKID RESISTANCE		SN N/D Points x Factor ___ x ___	0
V. TRAFFIC VOLUME TRAVEL SPEED		AADT 19810 MPH 55	12 5

Raters: ~~RIZENBERGS, P.E./ GROSSFELD~~ Burchett P.E. / Hollinger

Total 38.9

Date: 6 / 11 / 1992

Points Ranking ~~30~~ 23

ROADWAY CHARACTERISTICS

PCC AC AC/PCC
Curbs & Gutters Manholes Inlet Boxes

Shoulders High ____ Low 1/2
Width 10'
Type Gravel /AC

Industrial Haul Type ____
Patching (Percent) 20

CO RECOMMENDATIONS

Improvement Needed? Yes Marginal No
Type: Resurface (AC) Other ____
Preparation: Leveling & Wedging (Percent) 25
Milling (in.) ____ Other ____
Other: ____

STATEWIDE RANKING:
DISTRICT RANKING: ~~29~~ 30

Preparator: Cal

DISTRICT RECOMMENDATIONS

Cost Estimate: $198,200
Treatment Code: [1, 3] - D - II, I
Remarks: Milling will be essential

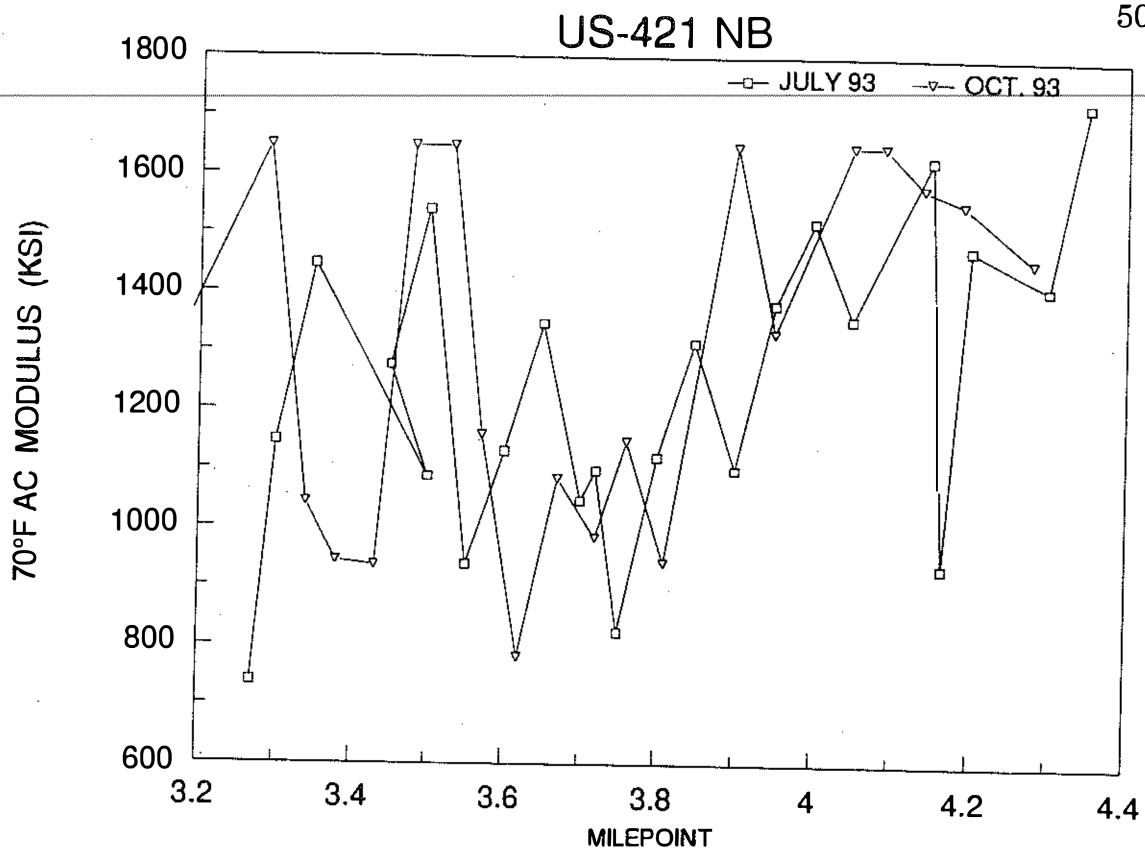
APPENDIX A2 - Falling Weight Deflectometer (FWD) Data

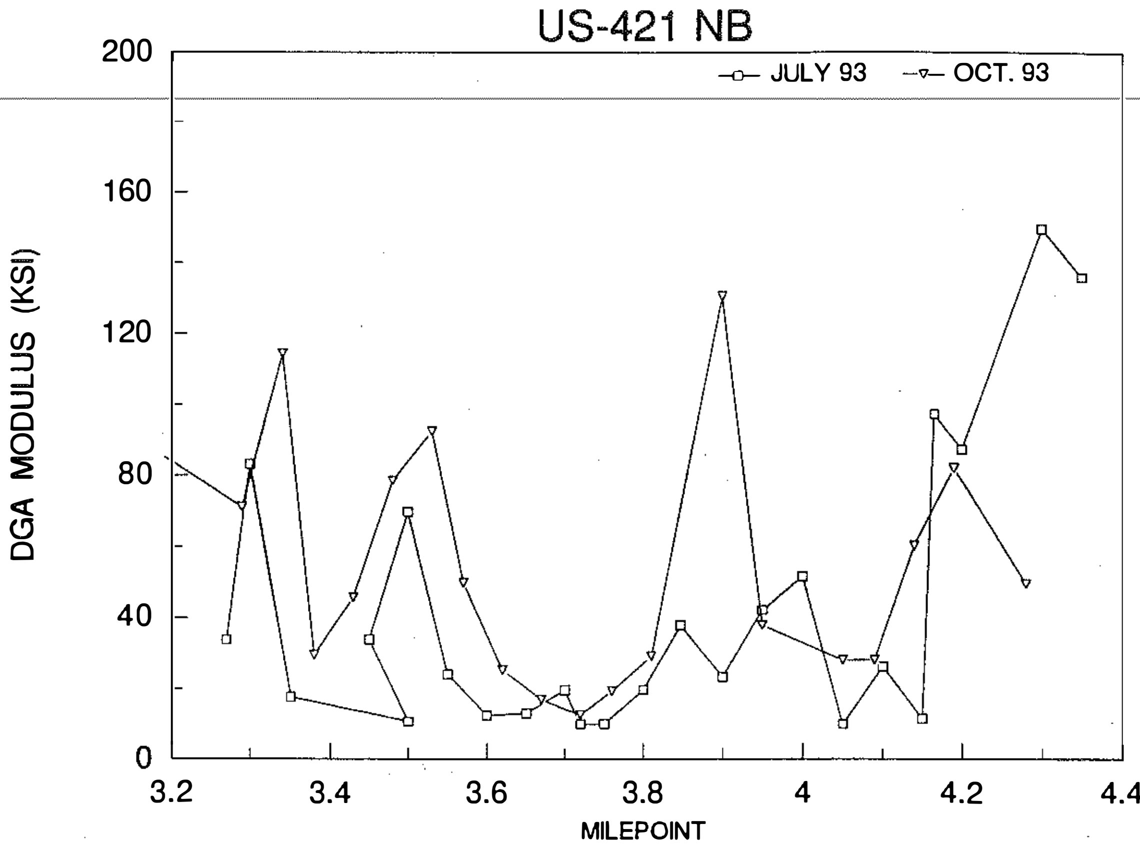
BACK-CALCULATED MODULUS VALUES
US-421-SB;07/01/93; T=107°F
AC=8 IN; DGA=12.25 IN

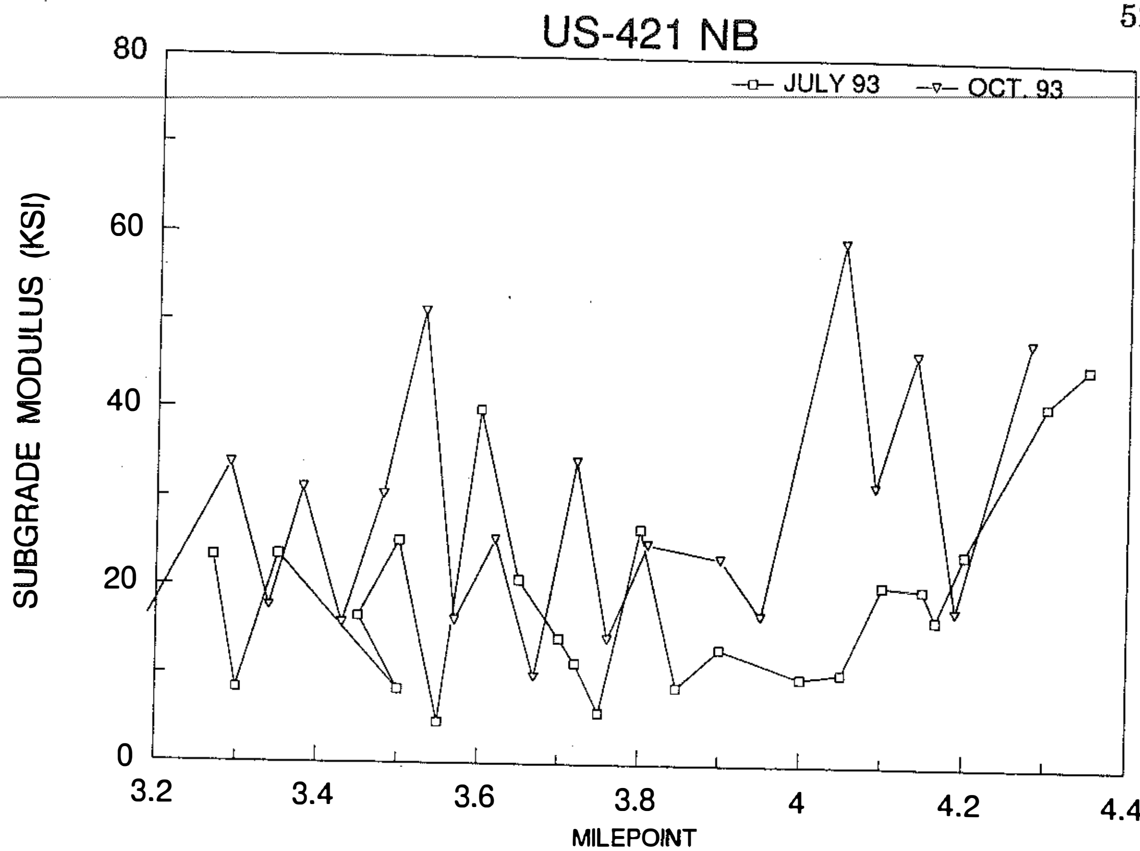
MP.	AC.MOD (KSI)	AC.MOD 70F(KSI)	DGA (KSI)	MOD.SUBGRADE (KSI)
3.27	340.00	739.1	33.9	23.35
3.30	528.00	1,147.8	83.0	8.38
3.35	665.67	1,447.1	17.7	23.53
3.50	500.00	1,087.0	10.7	8.33
3.45	587.50	1,277.2	34.0	16.63
3.50	708.67	1,540.6	69.7	25.13
3.55	431.00	937.0	24.1	4.65
3.60	520.00	1,130.4	12.5	39.93
3.65	619.75	1,347.3	13.1	20.80
3.70	481.25	1,046.2	19.6	14.23
3.72	505.00	1,097.8	10.0	11.40
3.75	378.75	823.4	10.1	5.80
3.80	515.67	1,121.0	19.7	26.63
3.85	605.00	1,315.2	37.9	8.75
3.90	506.00	1,100.0	23.4	13.18
3.95	635.00	1,380.4	42.3	
4.00	699.33	1,520.3	51.6	9.90
4.05	623.33	1,355.1	10.0	10.50
4.10			26.2	20.48
4.15	748.25	1,626.6	11.5	20.13
4.17	429.67	934.1	97.3	16.67
4.20	679.00	1,476.1	87.3	24.10
4.30	648.50	1,409.8	150.0	41.00
4.35	793.00	1,723.9	136.2	45.43
MEAN	571.67	1,242.8	43.0	19.08
STD	116.56	253.4	39.5	11.00
VARIANCE	1.35856e4	6.4204e4	1.5631e3	1.2092e2
CV (%)	20.4	20.4	92.0	57.6

BACK-CALCULATED MODULUS VALUES
US-421-SB;10/21/93; T=73-75°F
AC=8 IN; DGA=12.25 IN

MP.	AC.MOD (KSI)	AC.MOD 70F(KSI)	DGA MOD. (KSI)	SUBGRADE (KSI)
3.19	1,244.00	1,367.0	85.3	16.55
3.24				
3.29	1,500.00	1,648.4	71.0	33.75
3.34	949.00	1,042.9	114.5	17.70
3.38	858.00	942.9	29.6	31.05
3.43	850.50	934.6	45.8	15.80
3.48	1,500.00	1,648.4	78.5	30.37
3.53	1,500.00	1,648.4	92.3	51.07
3.57	1,054.00	1,158.2	49.9	16.25
3.62	711.00	781.3	25.3	25.33
3.67	986.50	1,084.1	17.0	9.88
3.72	895.25	983.8	12.7	34.20
3.76	1,044.25	1,147.5	19.3	14.20
3.81	856.00	940.7	29.3	24.90
3.90	1,500.00	1,648.4	130.6	23.35
3.95	1,212.50	1,332.4	38.0	16.95
4.00				
4.05	1,500.00	1,648.4	28.2	59.30
4.09	1,500.00	1,648.4	28.2	31.63
4.14	1,437.50	1,579.7	60.4	46.63
4.19	1,412.50	1,552.2	82.0	17.65
4.24				
4.28	1,324.67	1,455.7	49.6	48.17
4.33				
4.38				
4.43	1,500.00	1,648.4	132.4	74.77
4.47	1,500.00	1,648.4	136.8	53.08
4.50	1,500.00	1,648.4	132.4	24.37
MEAN	1,231.99	1,353.8	64.7	31.17
STD	275.78	303.1	40.8	16.52
VARIANCE	7.60551e4	9.1843e4	1.6611e3	2.7276e2
CV (%)	22.4	22.4	63.0	53.0


US-421 NB
JULY 93
OCT. 93
70°F AC MODULUS (KSI)
1800
1600
1400
1200
1000
800
600
3.2
3.4
3.6
3.8
4
4.2
4.4
MILEPOINT


US-421 NB
JULY 93
OCT. 93
DGA MODULUS (KSI)
200
160
120
80
40
0
3.2
3.4
3.6
3.8
4
4.2
4.4
MILEPOINT

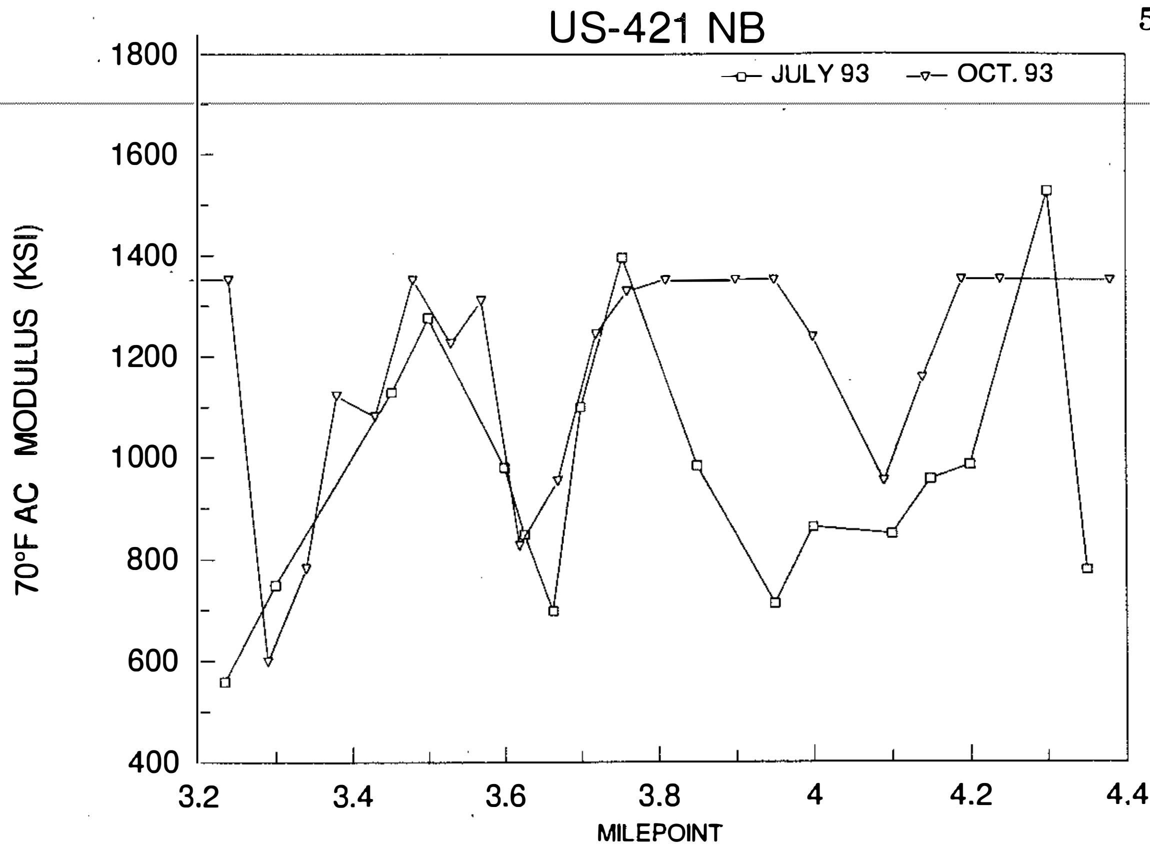

US-421 NB
JULY 93
OCT. 93
SUBGRADE MODULUS (KSI)
MILEPOINT
80
60
40
20
0
3.2
3.4
3.6
3.8
4
4.2
4.4

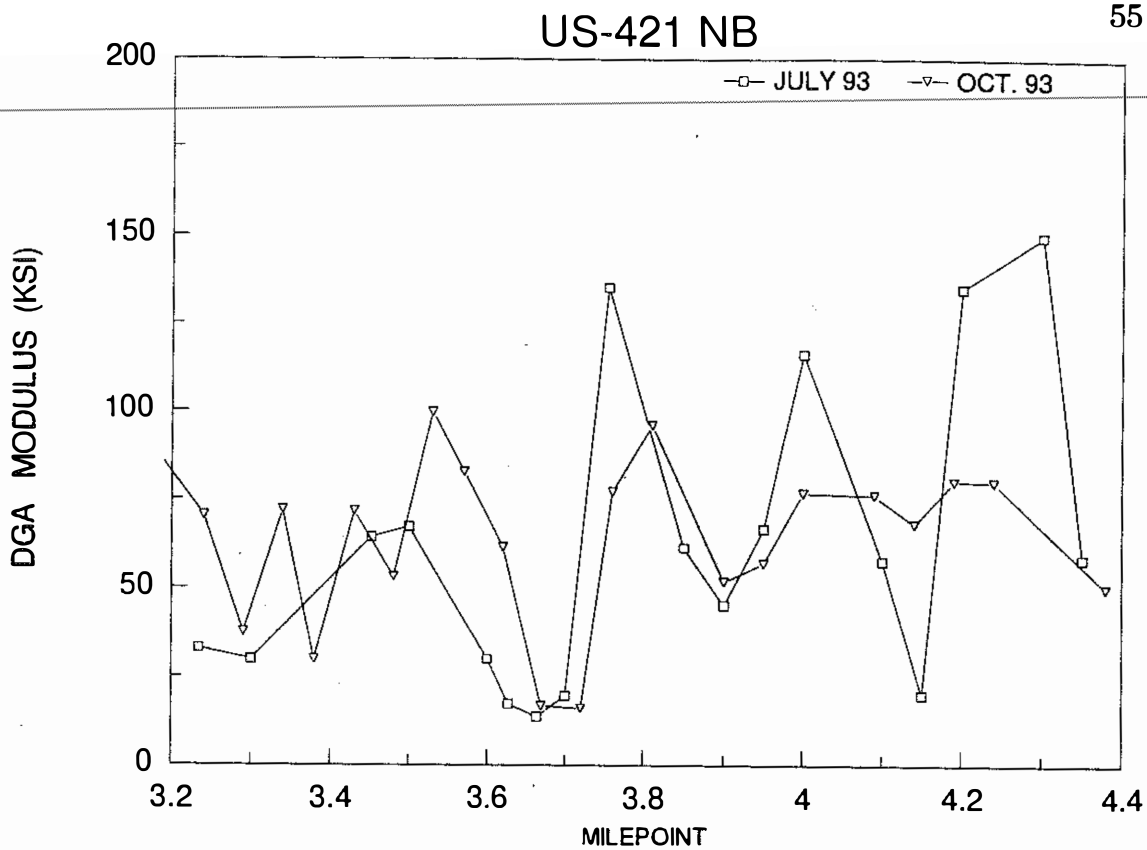
BACK-CALCULATED MODULUS VALUES
US-421-NB;07/01/93; T=85-87°F

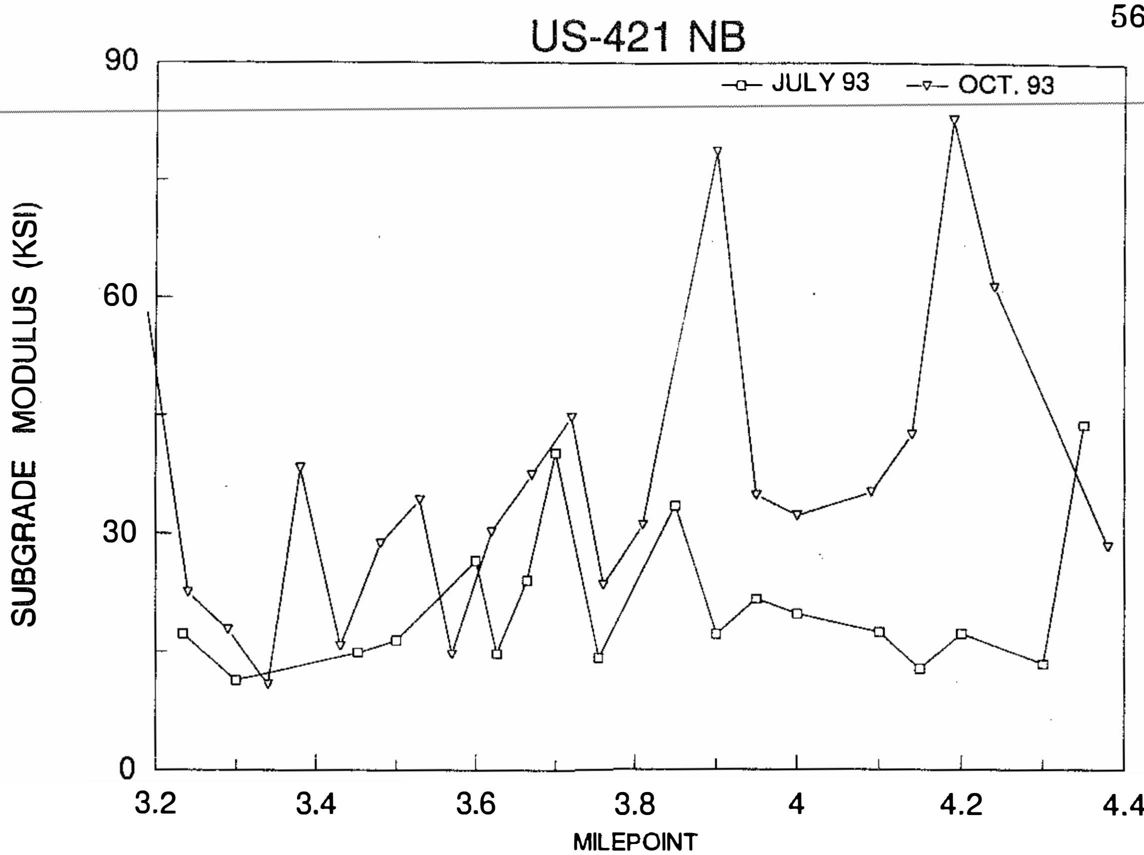
MP.	AC.MOD (KSI)	AC.MOD 70F(KSI)	DGA MOD. (KSI)	SUBGRADE (KSI)
3.23	385.5	558.7	32.9	17.20
3.30	517.3	749.6	29.8	11.43
3.45	779.0	1,129.0	64.4	14.90
3.50	881.0	1,276.8	67.3	16.40
3.60	676.5	980.4	29.9	26.55
3.63	585.8	848.9	17.2	14.75
3.66	482.0	698.6	13.7	24.08
3.70	758.3	1,099.0	19.6	40.17
3.75	962.7	1,395.2	135.1	14.28
3.85	678.3	983.1	61.4	33.63
3.90			45.2	17.37
3.95	491.7	712.6	66.8	21.85
4.00	595.5	863.0	116.2	19.95
4.10	586.0	849.3	57.7	17.60
4.15	661.0	958.0	20.0	13.03
4.20	679.7	985.0	135.1	17.43
4.30	1,054.0	1,527.5	150.0	13.63
4.35	537.5	779.0	58.5	43.95
MEAN	665.4	964.3	62.3	21.01
STD	172.5	250.0	42.5	9.13
VARIANCE	2.976e4	6.2508e4	1.8084e3	8.3332e1
CV (%)	25.9	25.9	68.3	43.5

BACK-CALCULATED MODULUS VALUES
US-421-NB;10/21/93; T=62-71°F

MP.	AC.MOD (KSI)	AC.MOD 70F(KSI)	DGA MOD. (KSI)	SUBGRADE (KSI)
3.19	1,500.0	1,351.4	85.3	58.07
3.24	1,500.0	1,351.4	70.4	22.53
3.29	664.5	598.6	37.5	17.78
3.34	868.0	782.0	72.0	10.83
3.38	1,245.5	1,122.1	29.8	38.25
3.43	1,200.3	1,081.3	71.7	15.73
3.48	1,500.0	1,351.4	53.2	28.78
3.53	1,361.3	1,226.4	99.7	34.27
3.57	1,454.3	1,310.1	82.8	14.68
3.62	918.0	827.0	61.5	30.25
3.67	1,059.0	954.1	16.7	37.45
3.72	1,380.8	1,243.9	16.1	44.70
3.76	1,474.0	1,327.9	77.2	23.60
3.81	1,500.0	1,351.4	96.0	31.20
3.90	1,500.0	1,351.4	51.9	78.70
3.95	1,500.0	1,351.4	57.1	35.00
4.00	1,373.8	1,237.6	76.7	32.35
4.09	1,058.0	953.2	76.2	35.40
4.14	1,283.8	1,156.5	68.2	42.73
4.19	1,500.0	1,351.4	80.3	82.80
4.24	1,500.0	1,351.4	80.1	61.60
4.38	1,500.0	1,351.4	50.1	28.55
MEAN	1,311.0	1,181.0	64.1	36.60
STD	242.5	218.4	22.6	18.62
VARIANCE	5.879e4	4.7716e4	5.0971e2	3.4657e2
CV (%)	18.5	18.5	35.2	50.9


US-421 NB
JULY 93
OCT. 93
70°F AC MODULUS (KSI)
1800
1600
1400
1200
1000
800
600
400
3.2
3.4
3.6
3.8
4
4.2
4.4
MILEPOINT

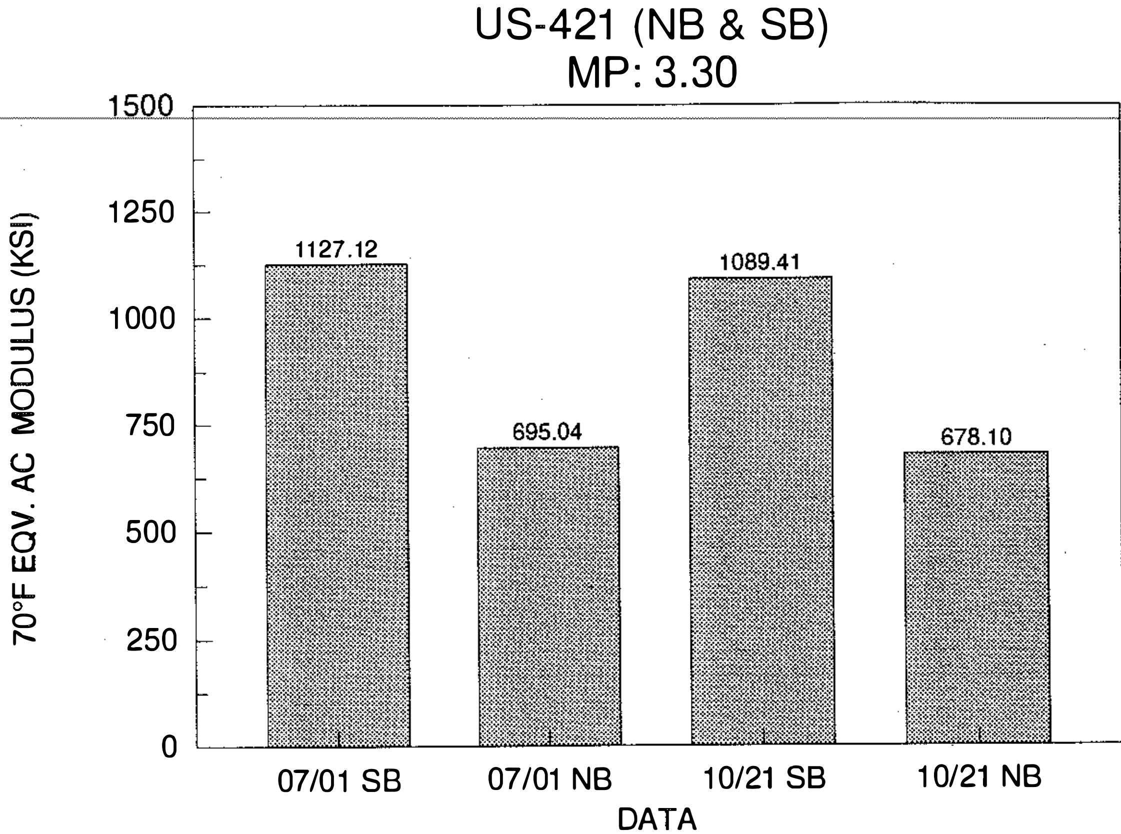

US-421 NB
JULY 93
OCT. 93
DGA MODULUS (KSI)
MILEPOINT
200
150
100
50
0
3.2
3.4
3.6
3.8
4
4.2
4.4

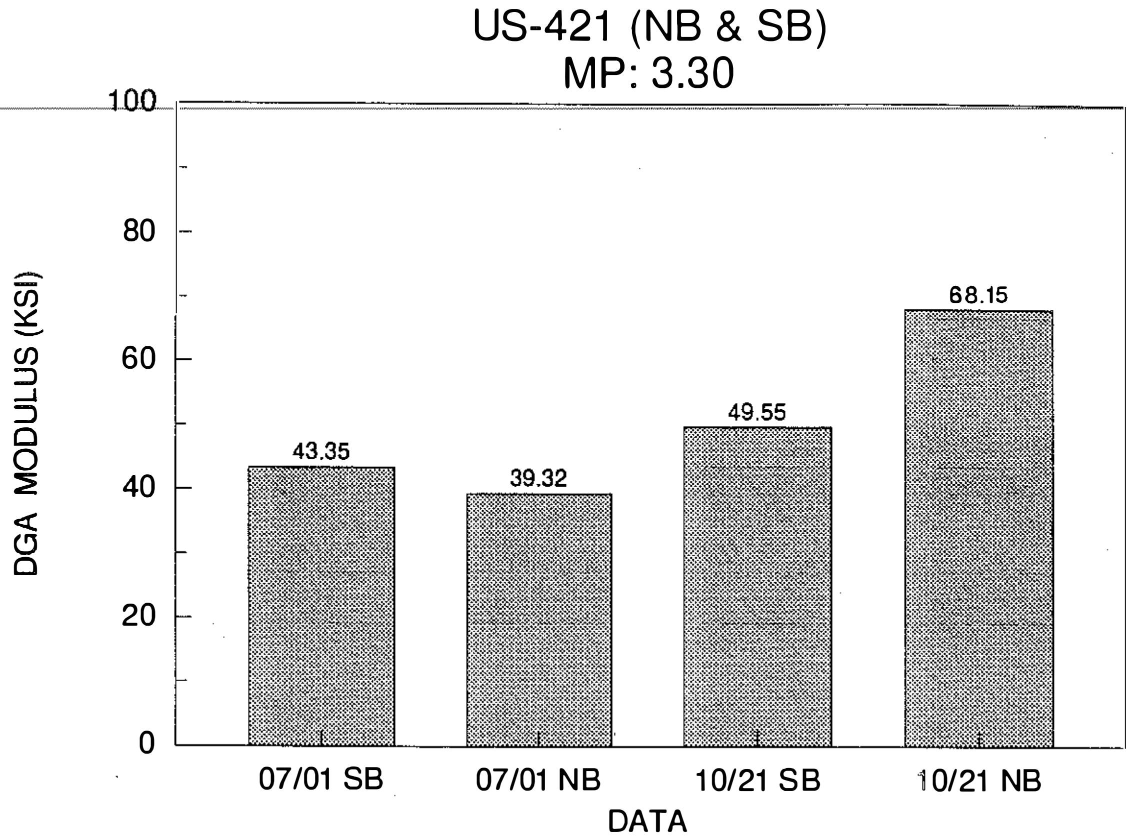

US-421 NB
JULY 93
OCT. 93
SUBGRADE MODULUS (KSI)
90
60
30
0
3.2
3.4
3.6
3.8
4
4.2
4.4
MILEPOINT

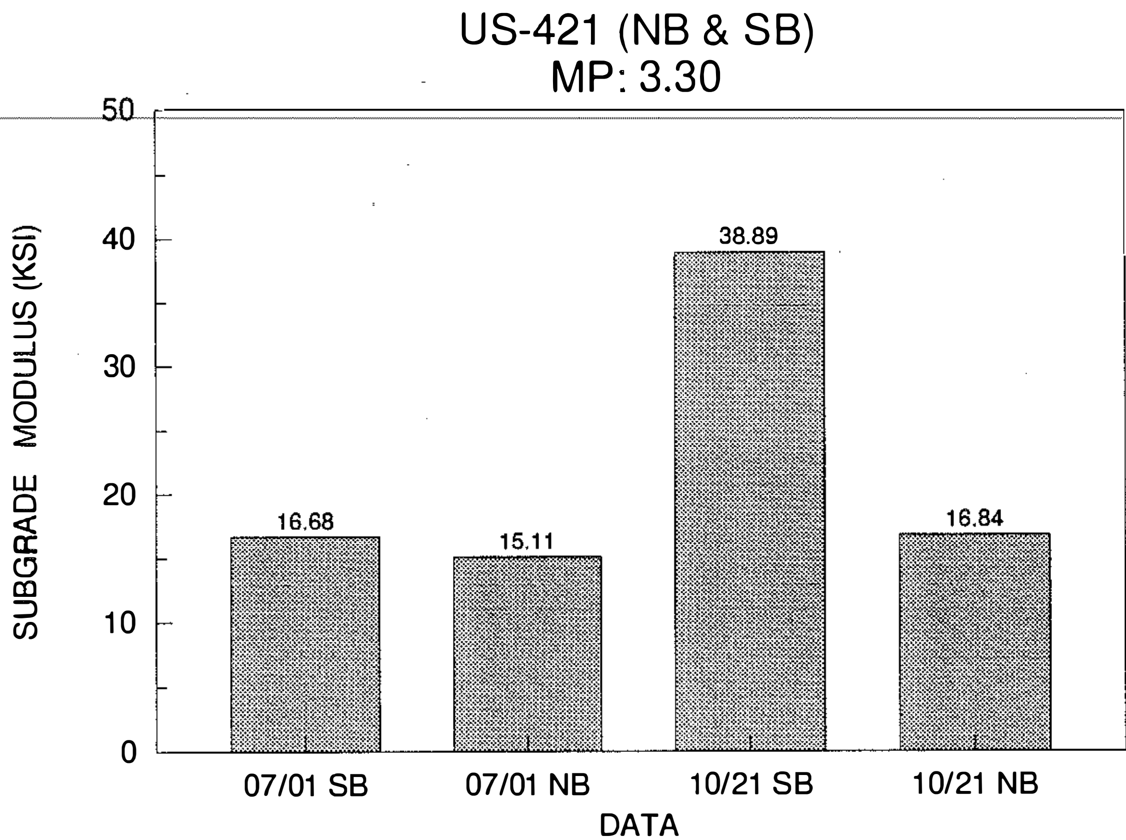
BACK-CALCULATED MODULUS VALUES US-421

MP : 3.3 THICKNESS: 8.5/11(BOTH JULY & OCT. DATA)

DATA	TEMP.	AC.MOD (KSI)	AC.MOD 70F(KSI)	DGA MOD. (KSI)	SUBGRADE MOD (KSI)		
07/01/93 SB	115	599.50	1,329.3	22.8	20.3		
		597.00	1,323.7	75.7	8.1	22.80	INCHES
		328.50	728.4	31.6	21.6		
	AVERAGE	508.33	1,127.1	43.4	16.7		
	AC MOD(70F)	1127.12					
07/01/93 NB	87	360.75	480.4	30.0	17.9		
		480.50	639.8	26.9	12.0	36.50	INCHES
		724.67	964.9	61.0	15.4		
	AVERAGE	521.97	695.0	39.3	15.1		
	AC MOD(70F)	695.04					
10/21/93 SB	75	1370.75	1,388.8	46.7	21.4		
		1500.00	1,519.8	47.6	47.6	56.90	INCHES
		355.00	359.7	54.3	47.7		
	AVERAGE	1075.25	1,089.4	49.6	38.9		
	AC MOD(70F)	1089.41					
10/21/93 NB	62	1497.25	1,086.5	69.9	22.2		
		573.00	415.8	36.3	18.0	36.80	INCHES
		733.00	531.9	98.3	10.3		
	AVERAGE	934.42	678.1	68.2	16.8		
	AC MOD(70F)	678.10					


US-421 (NB & SB)
MP: 3.30
70°F EQV. AC MODULUS (KSI)
1500
1250
1000
750
500
250
0
1127.12
695.04
1089.41
678.10
07/01 SB
07/01 NB
10/21 SB
10/21 NB
DATA

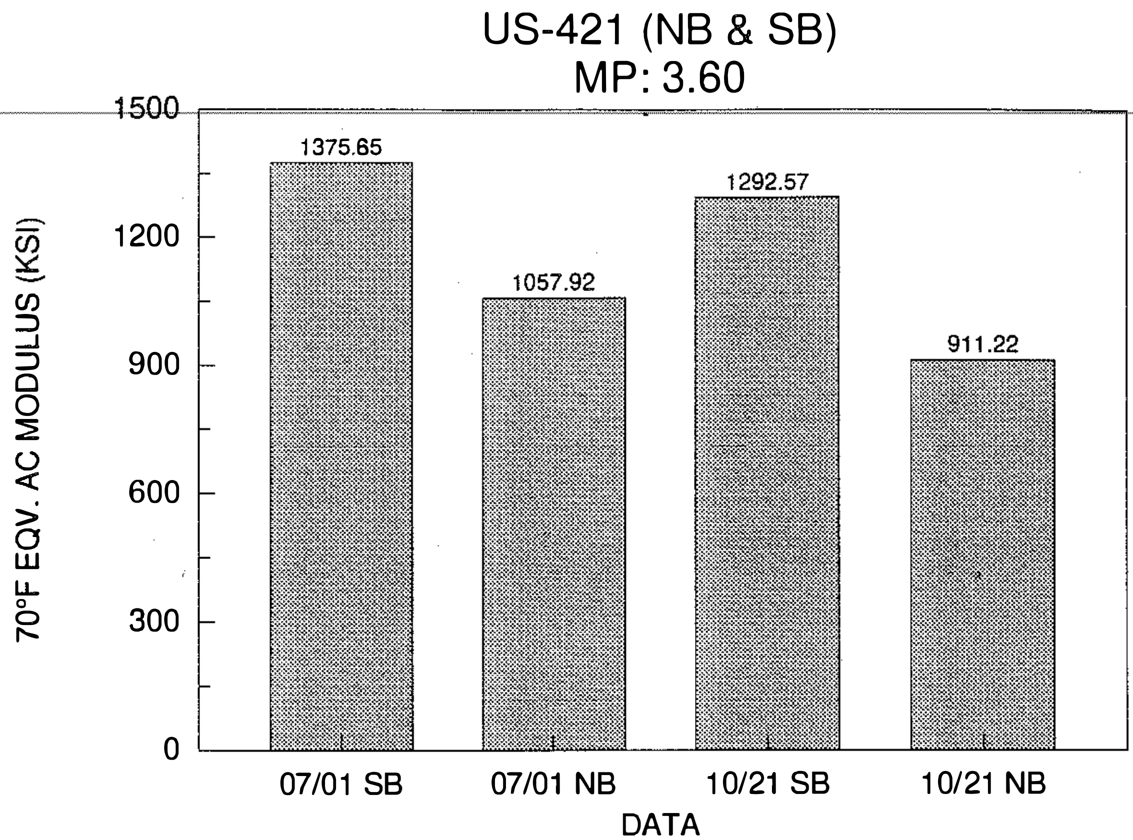

US-421 (NB & SB)
MP: 3.30
DGA MODULUS (KSI)
100
80
60
40
20
0
43.35
39.32
49.55
68.15
07/01 SB
07/01 NB
10/21 SB
10/21 NB
DATA

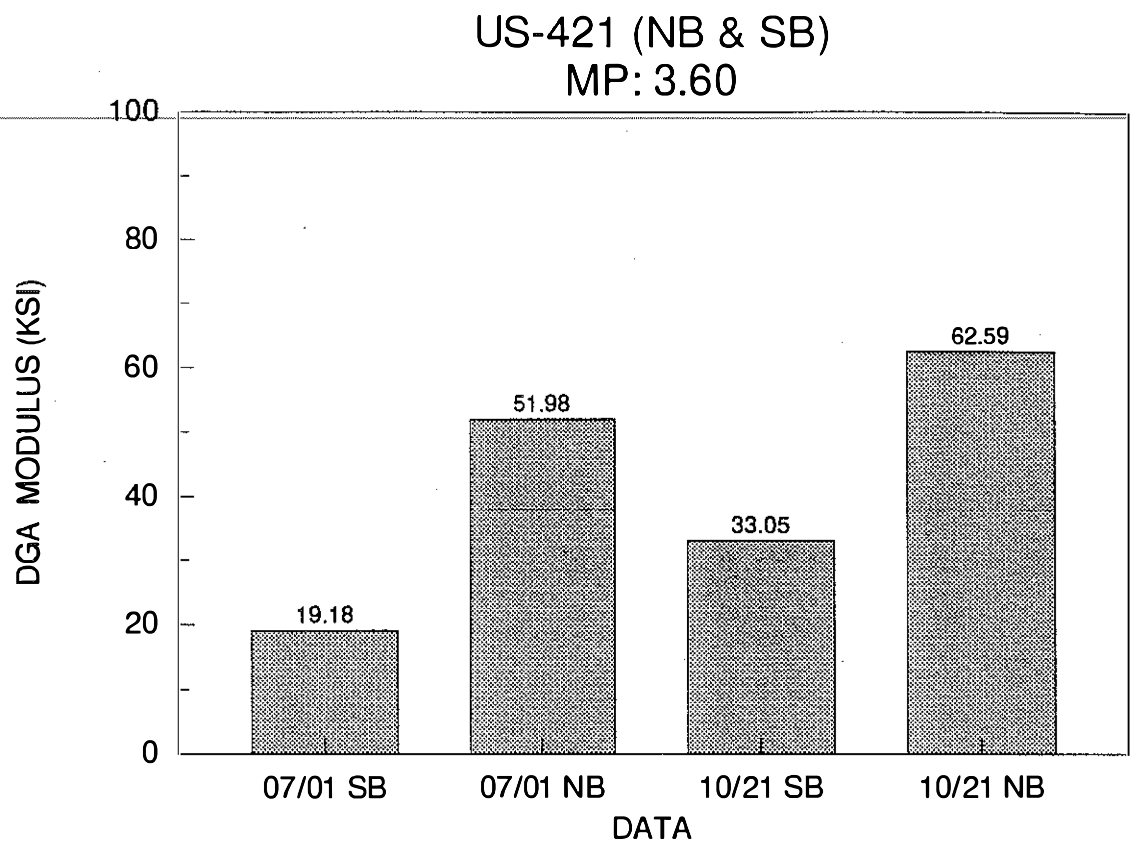

US-421 (NB & SB)
MP: 3.30
SUBGRADE MODULUS (KSI)
0
10
20
30
40
50
16.68
15.11
38.89
16.84
07/01 SB
07/01 NB
10/21 SB
10/21 NB
DATA

BACK-CALCULATED MODULUS VALUES US-421

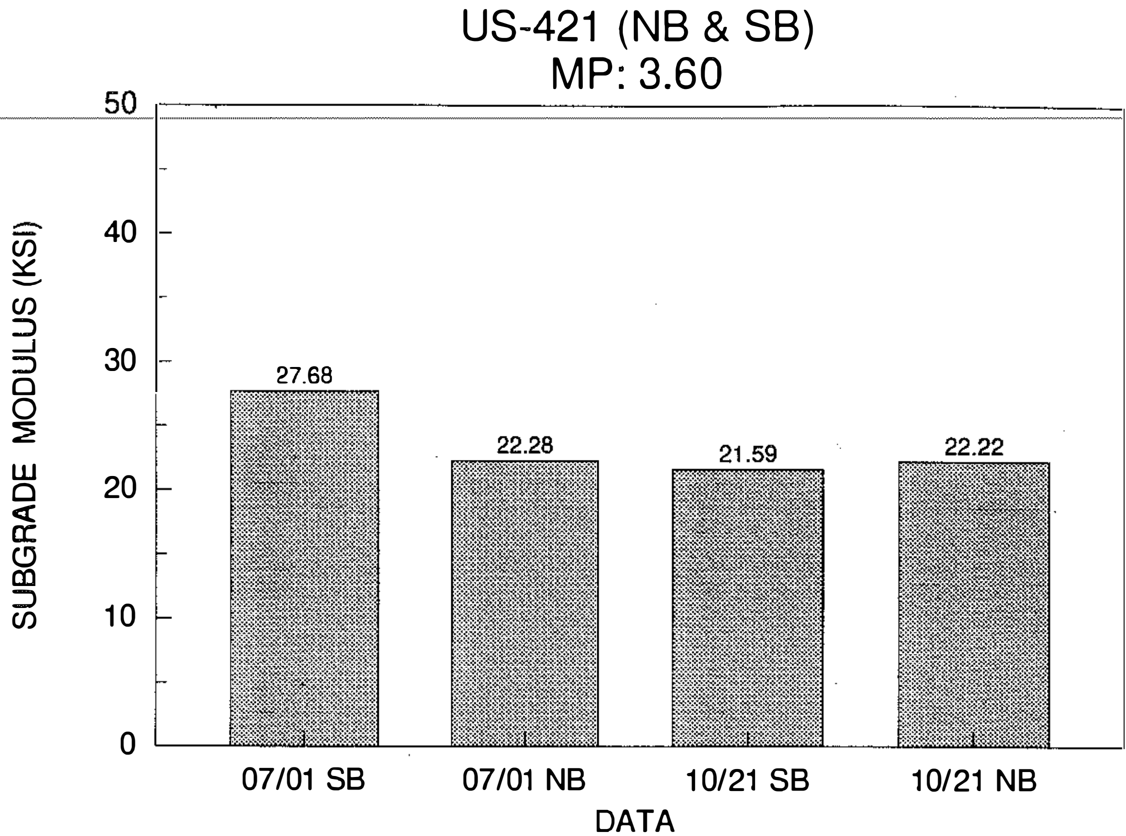
MP : 3.6 THICKNESS: 7.25/10.25(FOR BOTH JULY &OCT. DATA)

DATA	TEMP.	AC.MOD (KSI)	AC.MOD 70F(KSI)	DGA MOD. (KSI)	SUBGRADE MOD (KSI)		
07/01/93 SB	115	766.50	1699.557	11.8	31.8		
		615.75	1365.299	13.2	43.4	25.70	INCHES
		479.00	1062.084	32.6	7.9		
	AVERAGE	620.42	1375.647	19.2	27.7		
	AC MOD(70F)	1375.65					
07/01/93 NB	87	657.50	875.4993	20.5	26.0		
		763.75	1016.977	40.1	24.2	30.50	INCHES
		962.25	1281.292	95.4	16.7		
	AVERAGE	794.50	1057.923	52.0	22.3		
	AC MOD(70F)	1057.92					
10/21/93 SB	74	1500.00	1516.684	5.8	17.2		
		966.30	977.0475	24.7	34.5	42.50	INCHES
		1368.75	1383.974	68.7	13.1		
	AVERAGE	1278.35	1292.568	33.1	21.6		
	AC MOD(70F)	1292.57					
10/21/93 NB	65	1500.00	1180.173	58.1	18.1		
		1105.25	869.5909	59.6	29.2	39.80	INCHES
		869.25	683.9103	70.2	19.4		
	AVERAGE	1158.17	911.2248	62.6	22.2		
	AC MOD(70F)	911.22					


US-421 (NB & SB)
MP: 3.60
70°F EQV. AC MODULUS (KSI)
1500
1200
900
600
300
0
1375.65
1057.92
1292.57
911.22
07/01 SB
07/01 NB
10/21 SB
10/21 NB
DATA



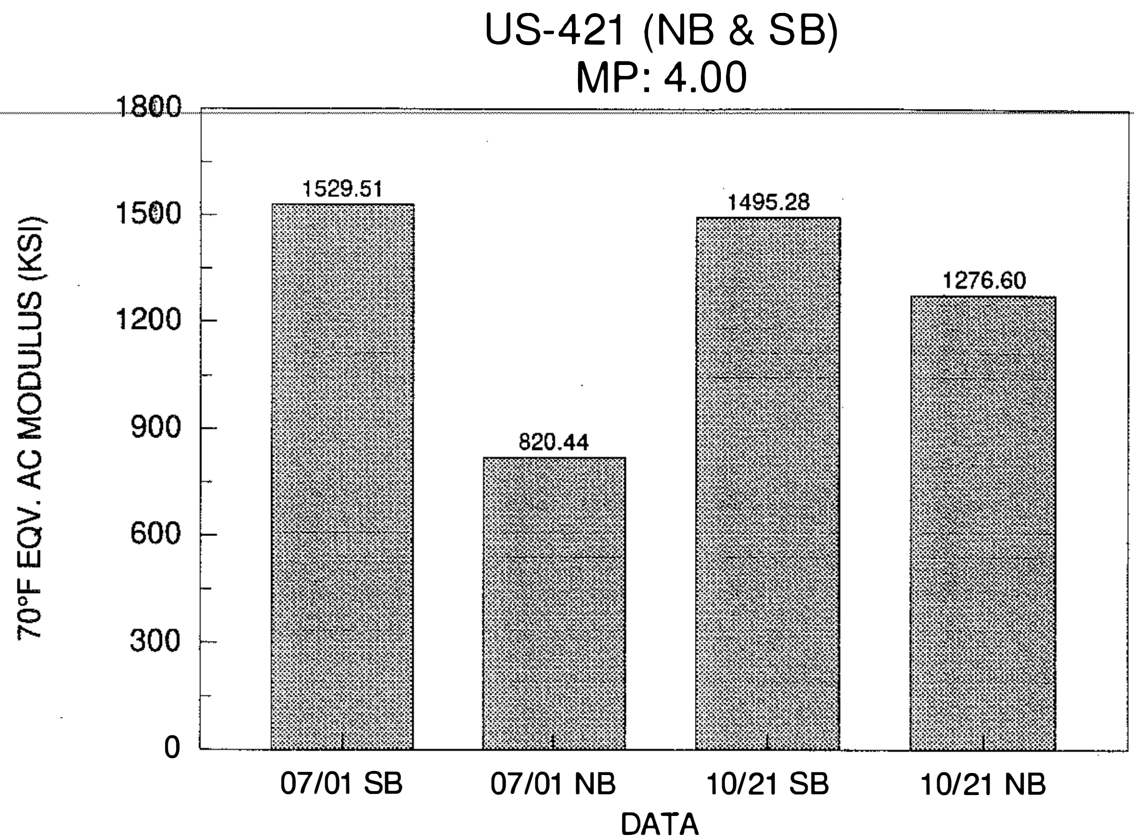
US-421 (NB & SB)
MP: 3.60
DGA MODULUS (KSI)
100
80
60
40
20
0
19.18
51.98
33.05
62.59
07/01 SB
07/01 NB
10/21 SB
10/21 NB
DATA

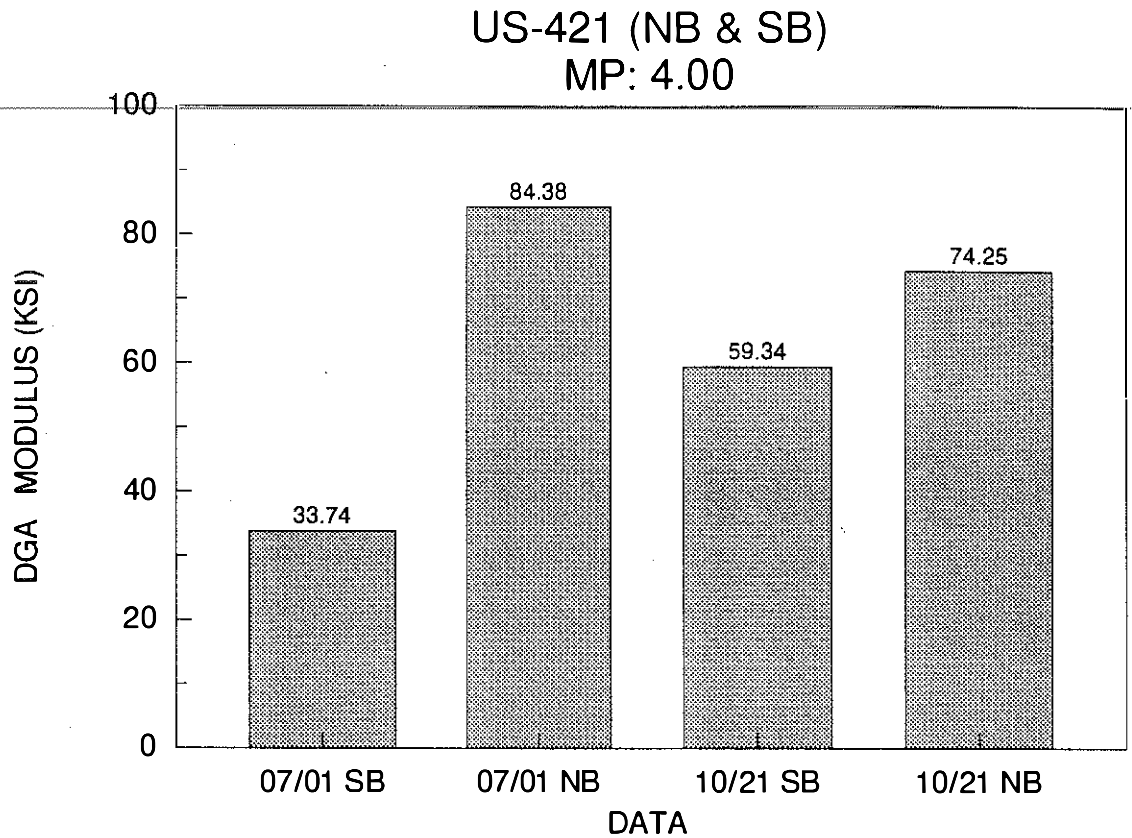

US-421 (NB & SB)
MP: 3.60
SUBGRADE MODULUS (KSI)
50
40
30
20
10
0
27.68
22.28
21.59
22.22
07/01 SB
07/01 NB
10/21 SB
10/21 NB
DATA

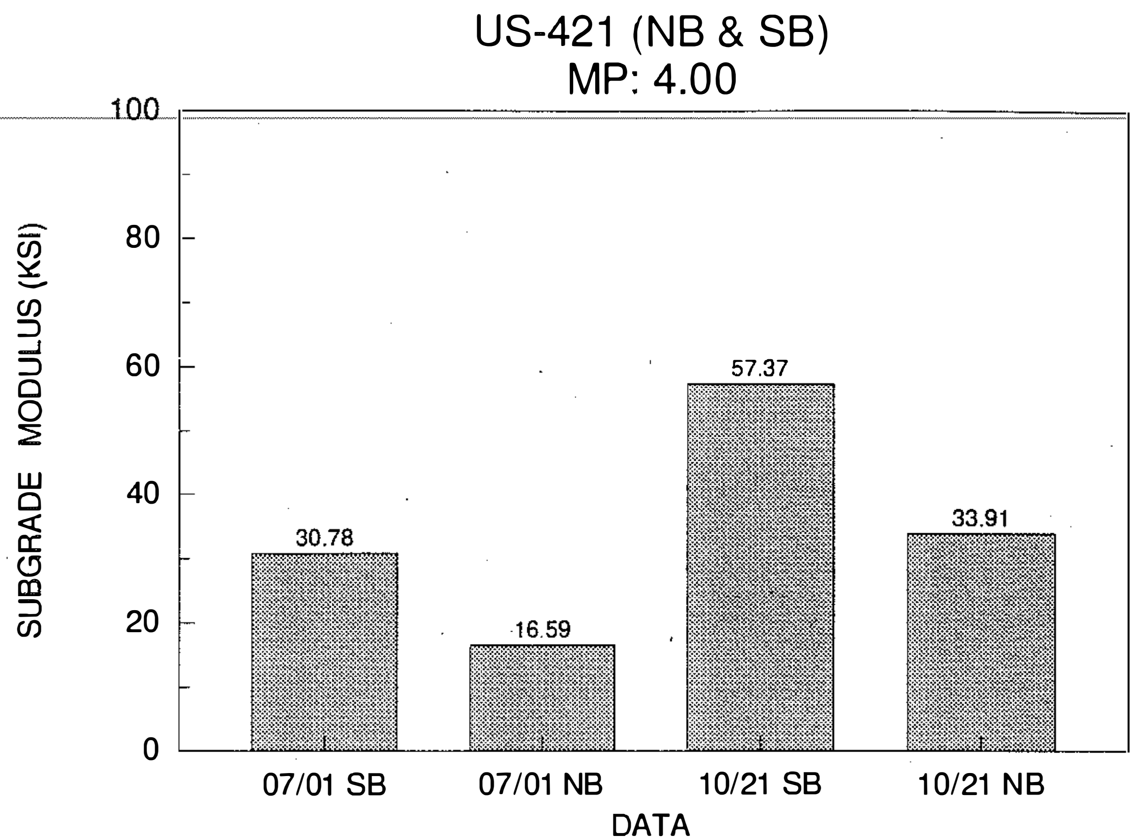
BACK-CALCULATED MODULUS VALUES US-421

MP : 4.0 THICKNESS: 7.50/11.5(FOR BOTH JULY &OCT. DATA)

DATA	TEMP.	AC.MOD (KSI)	AC.MOD 70F(KSI)	DGA MOD.(KSI)	SUBGRADE MOD (KSI)		
07/01/93 SB	111	704.25	1467.188	37.9	70.4		
		669.50	1394.792	47.7	11.7	14.70	INCHES
		828.75	1726.563	15.6	10.2		
	AVERAGE	734.17	1529.514	33.7	30.8		
	AC MOD(70F)	1529.51					
07/01/93 NB	85	668.00	852.0408	57.3	11.8		
		637.00	812.5	128.2	20.9	23.50	INCHES
		624.67	796.7687	67.6	17.1		
	AVERAGE	643.22	820.4365	84.4	16.6		
	AC MOD(70F)	820.44					
10/21/93 SB	74	1436.50	1452.477	32.5	15.3		
		1500.00	1516.684	111.6	89.5	42.00	INCHES
		1500.00	1516.684	34.0	67.4		
	AVERAGE	1478.83	1495.281	59.3	57.4		
	AC MOD(70F)	1495.28					
10/21/93 NB	68	1500.00	1276.596	41.9	41.7		
		1500.00	1276.596	67.5	31.4	31.70	INCHES
		1500.00	1276.596	113.4	28.7		
	AVERAGE	1500.00	1276.596	74.2	33.9		
	AC MOD(70F)	1276.60					


US-421 (NB & SB)
MP: 4.00
70°F EQV. AC MODULUS (KSI)
1800
1500
1200
900
600
300
0
1529.51
820.44
1495.28
1276.60
07/01 SB
07/01 NB
10/21 SB
10/21 NB
DATA

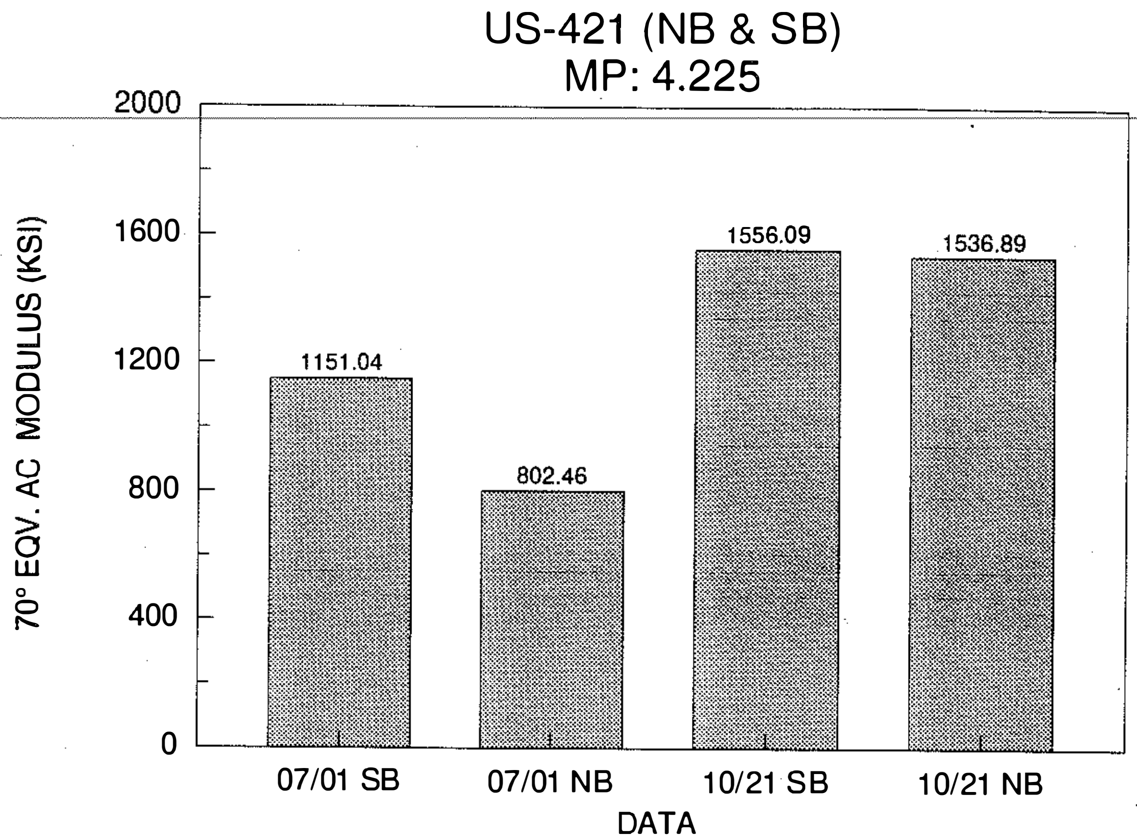

US-421 (NB & SB)
MP: 4.00
DGA MODULUS (KSI)
100
80
60
40
20
0
33.74
84.38
59.34
74.25
07/01 SB
07/01 NB
10/21 SB
10/21 NB
DATA

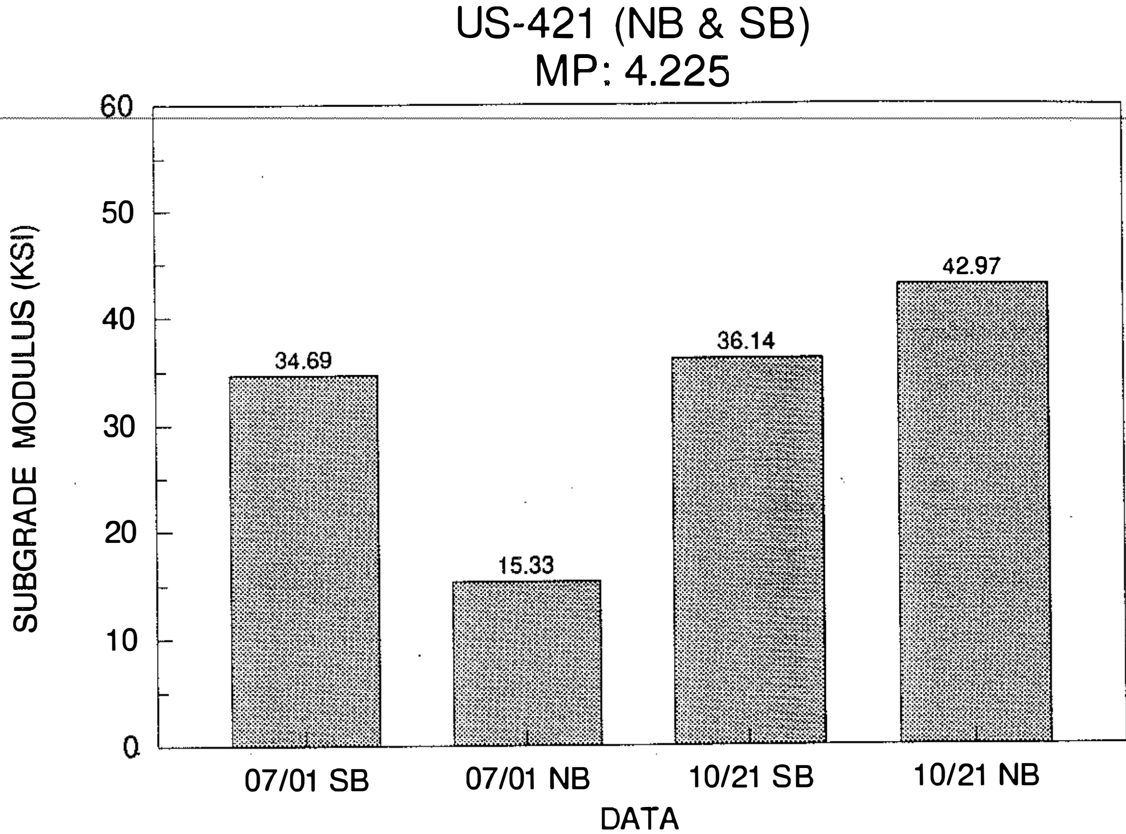

US-421 (NB & SB)
MP: 4.00
SUBGRADE MODULUS (KSI)
0
20
40
60
80
100
30.78
16.59
57.37
33.91
07/01 SB
07/01 NB
10/21 SB
10/21 NB
DATA

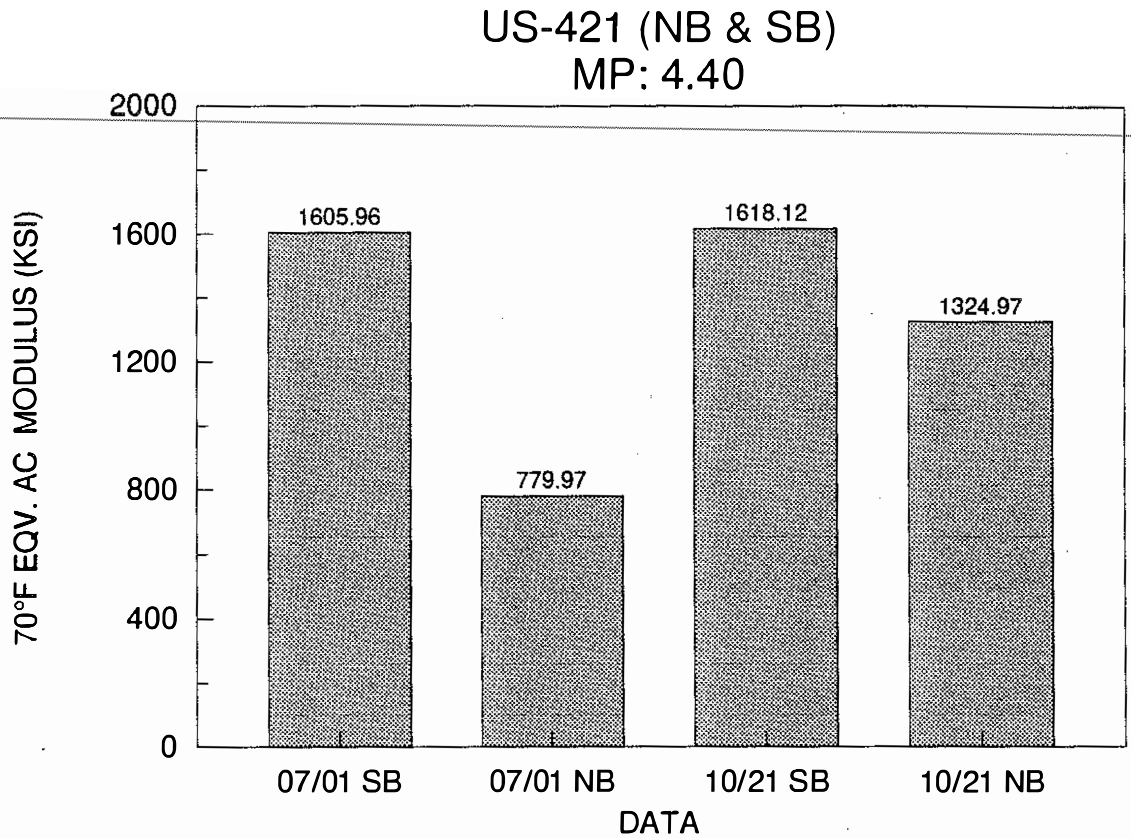
BACK-CALCULATED MODULUS VALUES US-421

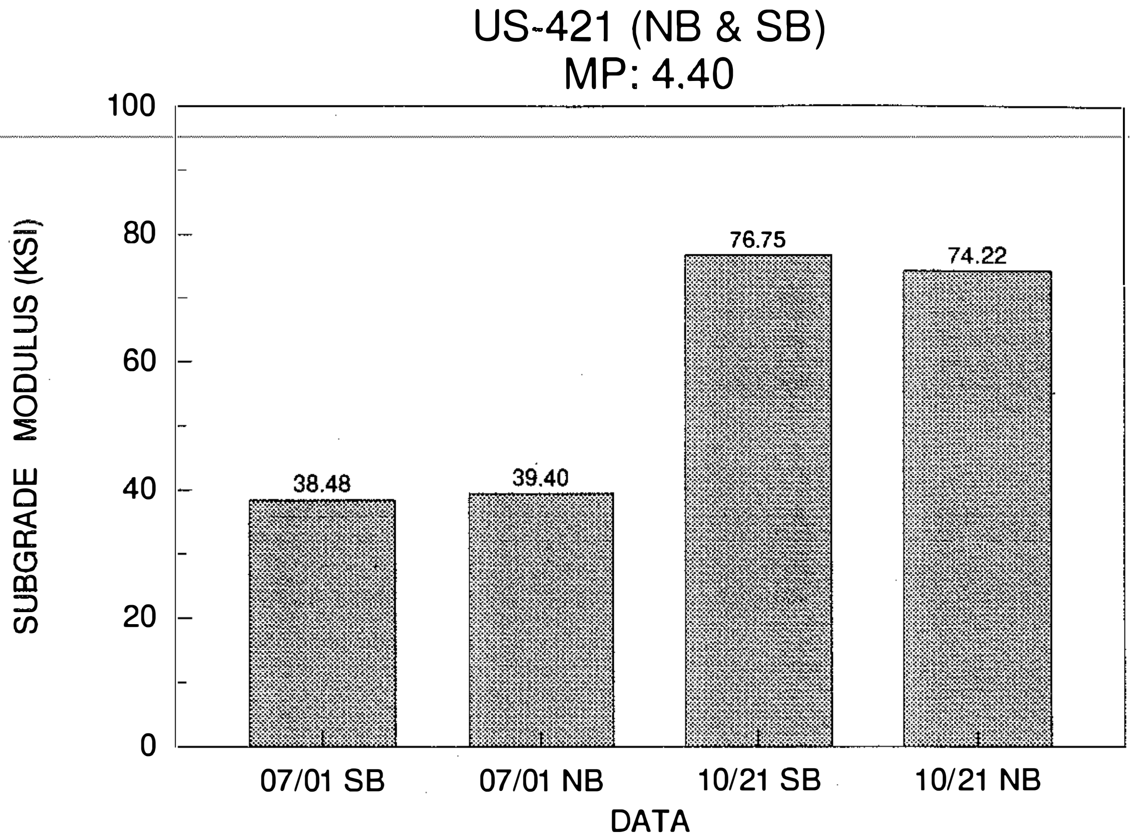
MP : 4.225 THICKNESS: 8.25/14(for both JULY & OCT. DATA)

DATA	TEMP.	AC.MOD (KSI)		DGA MOD. (KSI)	SUBGRADE MOD (KSI)		
07/01/93 SB	107	598.00	1167.969	147.1	56.0		
		677.00	1322.266	68.7	40.1	21.40	INCHES
		493.00	962.8906	77.5	8.0		
	AVERAGE	589.33	1151.042	97.7	34.7		
	AC MOD(70F)	1151.04					
07/01/93 NB	85	625.75	798.1505	17.2	15.4		
		632.50	806.7602	122.1	15.3	12.20	INCHES
	AVERAGE	629.13	802.4554	69.6	15.3		
	AC MOD(70F)	802.46					
10/21/93 SB	73	1431.00	1543.689	52.7			
		1396.50	1506.472	57.8	94.2	30.60	INCHES
		1500.00	1618.123	57.5	14.2		
	AVERAGE	1442.50	1556.095	56.0	36.1		
	AC MOD(70F)	1556.09					
10/21/93 NB	71	1500.00	1536.885	67.3	38.3		
		1500.00	1536.885	36.7	39.6	20.40	INCHES
		1500.00	1536.885	56.2	51.0		
	AVERAGE	1500.00	1536.885	53.4	43.0		
	AC MOD(70F)	1536.89					


US-421 (NB & SB)
MP: 4.225
70° EQV. AC MODULUS (KSI)
2000
1600
1200
800
400
0
1151.04
802.46
1556.09
1536.89
07/01 SB
07/01 NB
10/21 SB
10/21 NB
DATA


US-421 (NB & SB)
MP: 4.225
SUBGRADE MODULUS (KSI)
60
50
40
30
20
10
0
34.69
15.33
36.14
42.97
07/01 SB
07/01 NB
10/21 SB
10/21 NB
DATA


US-421 (NB & SB)
MP: 4.40
70°F EQV. AC MODULUS (KSI)
2000
1600
1200
800
400
0
1605.96
779.97
1618.12
1324.97
07/01 SB
07/01 NB
10/21 SB
10/21 NB
DATA


US-421 (NB & SB)
MP: 4.40
SUBGRADE MODULUS (KSI)
100
80
60
40
20
0
38.48
39.40
76.75
74.22
07/01 SB
07/01 NB
10/21 SB
10/21 NB
DATA

APPENDIX B - Material Properties

APPENDIX B1 - Binder Viscosity of Specimens in Chronological Order

DVGather+ V1.0 data Copyright 1992, Brookfield Engineering Labs

Date: 08/19/93 Model: 5HB
Time: 13:02 Spindle: CP51
File: CAN1 Sample: GF-80A (7.5%) 11:15am 7/14/93

Speed RPM	Torque %	Viscosity cP	Shear Stress D/Cm2	Shear Rate 1/Sec	Temperature C	Time Sec
2.5	54.6	447283.2	42939.2	9.6	60	15
2.5	54.3	444825.6	42703.3	9.6	60	15
2.5	54.6	447283.2	42939.2	9.6	60	15
2.5	54.7	448102.4	43017.8	9.6	60	15
2.5	54.3	444825.6	42703.3	9.6	60	15
2.5	54.5	446464.0	42860.5	9.6	60	15
2.5	54.6	447283.2	42939.2	9.6	60	15
2.5	54.7	448102.4	43017.8	9.6	60	15
2.5	54.7	448102.4	43017.8	9.6	60	15
2.5	54.3	444825.6	42703.3	9.6	60	15
2.5	54.5	446464.0	42860.5	9.6	60	15
2.5	54.8	448921.6	43096.5	9.6	60	15
2.5	54.5	446464.0	42860.5	9.6	60	15
2.5	54.4	445644.8	42781.9	9.6	60	15
2.5	54.5	446464.0	42860.5	9.6	60	15
2.5	54.4	445644.8	42781.9	9.6	60	15
2.5	54.8	448921.6	43096.5	9.6	60	15
2.5	54.2	444006.4	42624.6	9.6	60	15
2.5	54.5	446464.0	42860.5	9.6	60	15
2.5	54.7	448102.4	43017.8	9.6	60	15
2.5	54.4	445644.8	42781.9	9.6	60	15
2.5	54.4	445644.8	42781.9	9.6	60	15
2.5	54.4	445644.8	42781.9	9.6	60	15
2.5	54.5	446464.0	42860.5	9.6	60	15
2.5	54.5	446464.0	42860.5	9.6	60	15
2.5	54.2	444006.4	42624.6	9.6	60	15
2.5	54.4	445644.8	42781.9	9.6	60	15
2.5	54.7	448102.4	43017.8	9.6	60	15
2.5	54.5	446464.0	42860.5	9.6	60	15
2.5	54.3	444825.6	42703.3	9.6	60	15
Avg. Viscosity (cP)		446436.7				

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Date: 12/10/93 Model: 5HB
Time: 09:29 Spindle: CP51
File: CAN2 Sample: GF-80A (7.5%) 12:30pm 7/14/93

Speed RPM	Torque %	Viscosity cP	Shear Stress D/Cm2	Shear Rate 1/Sec	Temperature C	Time Sec
2.5	60.1	492339.2	47264.6	9.6	60	15
2.5	60.6	496435.2	47657.8	9.6	60	15
2.5	60.5	495616.0	47579.1	9.6	60	15
2.5	61.0	499712.0	47972.4	9.6	60	15
2.5	61.0	499712.0	47972.4	9.6	60	15
2.5	61.3	502169.6	48208.3	9.6	60	15
2.5	61.7	505446.4	48522.9	9.6	60	15
2.5	61.6	504627.2	48444.2	9.6	60	15
2.5	62.0	507904.0	48758.8	9.6	60	15
2.5	62.3	510361.6	48994.7	9.6	60	15
2.5	62.2	509542.4	48916.1	9.6	60	15
2.5	62.6	512819.2	49230.6	9.6	60	15
2.5	62.6	512819.2	49230.6	9.6	60	15
2.5	62.9	515276.8	49466.6	9.6	60	15
2.5	63.0	516096.0	49545.2	9.6	60	15
2.5	63.2	517734.4	49702.5	9.6	60	15
2.5	63.3	518553.6	49781.1	9.6	60	15
2.5	63.4	519372.8	49859.8	9.6	60	15
2.5	63.5	520192.0	49938.4	9.6	60	15
2.5	63.7	521830.4	50095.7	9.6	60	15
2.5	63.6	521011.2	50017.1	9.6	60	15
2.5	64.0	524288.0	50331.6	9.6	60	15
2.5	64.0	524288.0	50331.6	9.6	60	15
2.5	63.9	523468.8	50253.0	9.6	60	15
2.5	64.2	525926.4	50488.9	9.6	60	15
2.5	64.3	526745.6	50567.6	9.6	60	15
2.5	64.3	526745.6	50567.6	9.6	60	15
2.5	64.5	528384.0	50724.9	9.6	60	15
2.5	64.4	527564.8	50646.2	9.6	60	15
2.5	64.7	530022.4	50882.2	9.6	60	15
Avg. Viscosity (cP)		514566.8				

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Date: 12/10/93 Model: 5HB
Time: 11:50 Spindle: CP51
File: CAN3 Sample: GF-80A (7.5%) 1:00pm 7/14/93

Speed RPM	Torque %	Viscosity cP	Shear Stress D/Cm2	Shear Rate 1/Sec	Temperature C	Time Sec
2.5	50.2	411238.4	39478.9	9.6	60	15
2.5	50.1	410419.2	39400.2	9.6	60	15
2.5	50.5	413696.0	39714.8	9.6	60	15
2.5	50.7	415334.4	39872.1	9.6	60	15
2.5	50.4	412876.8	39636.2	9.6	60	15
2.5	50.6	414515.2	39793.5	9.6	60	15
2.5	50.7	415334.4	39872.1	9.6	60	15
2.5	50.8	416153.6	39950.7	9.6	60	15
2.5	50.7	415334.4	39872.1	9.6	60	15
2.5	50.5	413696.0	39714.8	9.6	60	15
2.5	50.6	414515.2	39793.5	9.6	60	15
2.5	50.9	416972.8	40029.4	9.6	60	15
2.5	50.6	414515.2	39793.5	9.6	60	15
2.5	50.7	415334.4	39872.1	9.6	60	15
2.5	50.9	416972.8	40029.4	9.6	60	15
2.5	50.8	416153.6	39950.7	9.6	60	15
2.5	50.6	414515.2	39793.5	9.6	60	15
2.5	50.4	412876.8	39636.2	9.6	60	15
2.5	50.8	416153.6	39950.7	9.6	60	15
2.5	50.8	416153.6	39950.7	9.6	60	15
2.5	50.3	412057.6	39557.5	9.6	60	15
2.5	50.6	414515.2	39793.5	9.6	60	15
2.5	50.6	414515.2	39793.5	9.6	60	15
2.5	50.6	414515.2	39793.5	9.6	60	15
2.5	50.4	412876.8	39636.2	9.6	60	15
2.5	50.3	412057.6	39557.5	9.6	60	15
2.5	50.6	414515.2	39793.5	9.6	60	15
2.5	50.5	413696.0	39714.8	9.6	60	15
2.5	50.3	412057.6	39557.5	9.6	60	15
2.5	50.3	412057.6	39557.5	9.6	60	15
Avg. Viscosity (cP)		414187.5				

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Date: 12/10/93 Model: 5HB
Time: 13:39 Spindle: CP51
File: CAN4 Sample: GF-80A (7.5%) 1:30pm 7/14/93

Speed RPM	Torque %	Viscosity cP	Shear Stress D/Cm2	Shear Rate 1/Sec	Temperature C	Time Sec
2.5	52.3	428441.6	41130.4	9.6	60	15
2.5	52.8	432537.6	41523.6	9.6	60	15
2.5	53.0	434176.0	41680.9	9.6	60	15
2.5	52.9	433356.8	41602.3	9.6	60	15
2.5	53.1	434995.2	41759.5	9.6	60	15
2.5	53.2	435814.4	41838.2	9.6	60	15
2.5	53.4	437452.8	41995.5	9.6	60	15
2.5	53.5	438272.0	42074.1	9.6	60	15
2.5	53.0	434176.0	41680.9	9.6	60	15
2.5	53.7	439910.4	42231.4	9.6	60	15
2.5	53.5	438272.0	42074.1	9.6	60	15
2.5	53.3	436633.6	41916.8	9.6	60	15
2.5	53.5	438272.0	42074.1	9.6	60	15
2.5	53.4	437452.8	41995.5	9.6	60	15
2.5	53.5	438272.0	42074.1	9.6	60	15
2.5	53.6	439091.2	42152.8	9.6	60	15
2.5	52.9	433356.8	41602.3	9.6	60	15
2.5	53.4	437452.8	41995.5	9.6	60	15
2.5	53.4	437452.8	41995.5	9.6	60	15
2.5	53.0	434176.0	41680.9	9.6	60	15
2.5	53.2	435814.4	41838.2	9.6	60	15
2.5	52.9	433356.8	41602.3	9.6	60	15
2.5	53.1	434995.2	41759.5	9.6	60	15
2.5	53.2	435814.4	41838.2	9.6	60	15
2.5	52.5	430080.0	41287.7	9.6	60	15
2.5	52.9	433356.8	41602.3	9.6	60	15
2.5	52.8	432537.6	41523.6	9.6	60	15
2.5	52.6	430899.2	41366.3	9.6	60	15
2.5	52.8	432537.6	41523.6	9.6	60	15
2.5	52.5	430080.0	41287.7	9.6	60	15
Avg. Viscosity (c		434967.9				

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Date: 12/10/93 Model: 5HB
Time: 15:29 Spindle: CP51
File: CAN5 Sample: GF-80A (7.5%) 11:30am 7/15/93

Speed RPM	Torque %	Viscosity cP	Shear Stress D/Cm2	Shear Rate 1/Sec	Temperature C	Time Sec
2.5	61.0	499712.0	47972.4	9.6	60	15
2.5	61.4	502988.8	48286.9	9.6	60	15
2.5	61.2	501350.4	48129.6	9.6	60	15
2.5	61.3	502169.6	48208.3	9.6	60	15
2.5	61.3	502169.6	48208.3	9.6	60	15
2.5	61.0	499712.0	47972.4	9.6	60	15
2.5	61.3	502169.6	48208.3	9.6	60	15
2.5	61.4	502988.8	48286.9	9.6	60	15
2.5	60.7	497254.4	47736.4	9.6	60	15
2.5	61.1	500531.2	48051.0	9.6	60	15
2.5	61.0	499712.0	47972.4	9.6	60	15
2.5	61.1	500531.2	48051.0	9.6	60	15
2.5	60.9	498892.8	47893.7	9.6	60	15
2.5	60.7	497254.4	47736.4	9.6	60	15
2.5	60.9	498892.8	47893.7	9.6	60	15
2.5	61.1	500531.2	48051.0	9.6	60	15
2.5	60.5	495616.0	47579.1	9.6	60	15
2.5	60.8	498073.6	47815.1	9.6	60	15
2.5	60.7	497254.4	47736.4	9.6	60	15
2.5	60.8	498073.6	47815.1	9.6	60	15
2.5	60.7	497254.4	47736.4	9.6	60	15
2.5	60.4	494796.8	47500.5	9.6	60	15
2.5	60.6	496435.2	47657.8	9.6	60	15
2.5	60.8	498073.6	47815.1	9.6	60	15
2.5	60.1	492339.2	47264.6	9.6	60	15
2.5	60.4	494796.8	47500.5	9.6	60	15
2.5	60.4	494796.8	47500.5	9.6	60	15
2.5	60.4	494796.8	47500.5	9.6	60	15
2.5	60.5	495616.0	47579.1	9.6	60	15
2.5	60.1	492339.2	47264.6	9.6	60	15
Avg. Viscosity (cP)		498237.4				

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Date: 12/13/93 Model: 5HB
Time: 01:44 Spindle: CP51
File: CAN6 Sample: GF-80A (7.5%) 12:30pm 7/15/93

Speed RPM	Torque %	Viscosity cP	Shear Stress D/Cm2	Shear Rate 1/Sec	Temperature C	Time Sec
2.5	53.1	434995.2	41759.5	9.6	60	15
2.5	53.2	435814.4	41838.2	9.6	60	15
2.5	53.4	437452.8	41995.5	9.6	60	15
2.5	53.2	435814.4	41838.2	9.6	60	15
2.5	53.6	439091.2	42152.8	9.6	60	15
2.5	53.5	438272.0	42074.1	9.6	60	15
2.5	53.5	438272.0	42074.1	9.6	60	15
2.5	53.6	439091.2	42152.8	9.6	60	15
2.5	53.8	440729.6	42310.0	9.6	60	15
2.5	53.6	439091.2	42152.8	9.6	60	15
2.5	53.8	440729.6	42310.0	9.6	60	15
2.5	53.7	439910.4	42231.4	9.6	60	15
2.5	53.9	441548.8	42388.7	9.6	60	15
2.5	53.8	440729.6	42310.0	9.6	60	15
2.5	53.9	441548.8	42388.7	9.6	60	15
2.5	53.8	440729.6	42310.0	9.6	60	15
2.5	53.8	440729.6	42310.0	9.6	60	15
2.5	53.9	441548.8	42388.7	9.6	60	15
2.5	53.9	441548.8	42388.7	9.6	60	15
2.5	53.6	439091.2	42152.8	9.6	60	15
2.5	54.0	442368.0	42467.3	9.6	60	15
2.5	53.7	439910.4	42231.4	9.6	60	15
2.5	53.8	440729.6	42310.0	9.6	60	15
2.5	53.8	440729.6	42310.0	9.6	60	15
2.5	53.9	441548.8	42388.7	9.6	60	15
2.5	53.8	440729.6	42310.0	9.6	60	15
2.5	53.9	441548.8	42388.7	9.6	60	15
2.5	53.6	439091.2	42152.8	9.6	60	15
2.5	53.9	441548.8	42388.7	9.6	60	15
2.5	53.6	439091.2	42152.8	9.6	60	15
Avg. Viscosity (cP)		439801.2				

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Date: 12/13/93 Model: 5HB
Time: 03:55 Spindle: CP51
File: CAN7 Sample: GF-80A (75%) 1:00pm 7/15/93

Speed RPM	Torque %	Viscosity cP	Shear Stress D/Cm2	Shear Rate 1/Sec	Temperature C	Time Sec
2.5	53.4	437452.8	41995.5	9.6	60	15
2.5	53.5	438272.0	42074.1	9.6	60	15
2.5	53.7	439910.4	42231.4	9.6	60	15
2.5	53.8	440729.6	42310.0	9.6	60	15
2.5	54.0	442368.0	42467.3	9.6	60	15
2.5	53.8	440729.6	42310.0	9.6	60	15
2.5	54.2	444006.4	42624.6	9.6	60	15
2.5	54.3	444825.6	42703.3	9.6	60	15
2.5	54.0	442368.0	42467.3	9.6	60	15
2.5	54.4	445644.8	42781.9	9.6	60	15
2.5	54.4	445644.8	42781.9	9.6	60	15
2.5	54.5	446464.0	42860.5	9.6	60	15
2.5	54.6	447283.2	42939.2	9.6	60	15
2.5	54.2	444006.4	42624.6	9.6	60	15
2.5	54.6	447283.2	42939.2	9.6	60	15
2.5	54.7	448102.4	43017.8	9.6	60	15
2.5	54.4	445644.8	42781.9	9.6	60	15
2.5	54.6	447283.2	42939.2	9.6	60	15
2.5	54.5	446464.0	42860.5	9.6	60	15
2.5	54.5	446464.0	42860.5	9.6	60	15
2.5	54.8	448921.6	43096.5	9.6	60	15
2.5	54.3	444825.6	42703.3	9.6	60	15
2.5	54.5	446464.0	42860.5	9.6	60	15
2.5	54.7	448102.4	43017.8	9.6	60	15
2.5	54.3	444825.6	42703.3	9.6	60	15
2.5	54.5	446464.0	42860.5	9.6	60	15
2.5	54.5	446464.0	42860.5	9.6	60	15
2.5	54.5	446464.0	42860.5	9.6	60	15
2.5	54.6	447283.2	42939.2	9.6	60	15
2.5	54.1	443187.2	42546.0	9.6	60	15

Avg. Viscosity (cP) 444798.3

APPENDIX B2 - Inventory of HMA Specimens Compacted by KTC

Regular AK-Surface Mix (4"pills) Project: P-150
(compacted at 265 F unless otherwise noted)

Pill #	OD	Sat.	SSD	Spec. Grav. (Bulk)	% Air Voids	Compaction (# Blows)	Test Performed on Sample
1	1199.3	689.1	1200.1	2.3470	6.0838	75	STABILITY
2	1194.9	688.6	1195.7	2.3563	5.7087	75	STABILITY
3	1214.5	700.6	1215.4	2.3592	5.5955	75	STABILITY
4	1193.7	683.5	1195.1	2.3333	6.6319	75	
5	1195.1	686.2	1196.5	2.3420	6.2843	75	
6	1202.7	687.1	1205.5	2.3200	7.1619	75	PRACTICE (Mr)
7	1196.5	684.2	1199.1	2.3238	7.0127	75	PRACTICE (Mr)
8	1194.9	684.2	1196.3	2.3333	6.6293	75	
9	1208.8	693.0	1210.5	2.3358	6.5288	75	
10	1179.5	674.7	1181.8	2.3260	6.9239	75	PRACTICE (Mr)
11	1175.0	674.6	1177.0	2.3388	6.4116	75	
12	1187.9	680.9	1189.5	2.3356	6.5375	75	
13	1213.3	692.6	1216.3	2.3168	7.2915	75	PRACTICE (Mr)
14	1174.5	667.4	1178.1	2.2998	7.9718	75	PRACTICE (Mr)
15	1212.6	694.1	1215.8	2.3243	6.9898	75	PRACTICE (Mr)
16	1190.6	680.9	1194.0	2.3204	7.1466	75	PRACTICE (Mr)
A1	1202.1	692.8	1205.5	2.3446	6.1766	75	RES. MOD. (77F)
A2	1202.8	692.9	1203.4	2.3561	5.7174	75	RES. MOD. (77F)
A3	1204.9	694.1	1205.8	2.3547	5.7743	75	RES. MOD. (77F)
A4	1213.6	697.4	1214.4	2.3474	6.0669	75	RES. MOD. (77F)
A5	1203.9	693.1	1204.8	2.3527	5.8525	75	RES. MOD. (104F)
A6	1222.6	701.3	1223.8	2.3399	6.3664	75	RES. MOD. (104F)
P1	1208.5	694.8	1209.7	2.3471	5.8918	75	RES. MOD. (32F)
P2	1200.1	690.1	1201.2	2.3481	5.8511	75	RES. MOD. (32F)
P3	1208.9	696.3	1210.3	2.3519	5.6958	75	RES. MOD. (32F)
P4	1206.5	695.4	1207.7	2.3551	5.5708	75	RES. MOD. (104F)

Regular AK-Surface Mix (4"pills) Continued

Pill #	OD	Sat.	SSD	Spec. Grav. (Bulk)	% Air Voids	Compaction (# Blows)	Test Performed on Sample
N1	1201.1	685.7	1204.0	2.3174	7.0816	50	TSR (SAT.)
N2	1207.7	689.2	1210.5	2.3167	7.1087	50	
N3	1200.1	685.3	1202.0	2.3226	6.8715	50	TSR (DRY)
N4	1199.7	684.4	1201.2	2.3214	6.9206	50	TSR (SAT.)
N5	1192.9	681.1	1195.0	2.3213	6.9259	50	
N6	1197.8	682.6	1199.0	2.3195	6.9960	50	
N7	1200.5	685.4	1202.1	2.3234	6.8405	50	
N8	1206.0	687.3	1207.9	2.3166	7.1148	50	TSR (DRY)
N9	1210.9	691.9	1214.5	2.3171	7.0943	50	
O1	1217.1	695.7	1221.0	2.3170	7.0986	50	
O2	1198.9	684.2	1200.8	2.3208	6.9466	50	TSR (DRY)
O3	1214.8	693.3	1216.8	2.3205	6.9553	50	TSR (SAT.)
1 (7-16)	1202.0	702.9	1202.5	2.4059	3.6860	PLANT MADE	RES. MOD. (ALL)
2 (7-16)	1199.7	702.5	1200.3	2.4100	3.5227	PLANT MADE	RES. MOD. (ALL)
3 (7-16)	1198.8	698.8	1199.3	2.3952	4.1151	PLANT MADE	RES. MOD. (ALL)
I1I	1191.1	679.9	1192.3	2.3246	6.9435	75 @ 240F	
I2I	1195.5	677.9	1198.1	2.2982	8.0002	75 @ 240F	
I3I	1197.4	682.9	1200.1	2.3152	7.3195	75 @ 240F	
75-1	1198.1	681.0	1211.8	2.2572	9.6414	75 @ 240F	
75-2	1187.6	680.7	1193.1	2.3177	7.2170	75 @ 240F	
75-3	1218.8	697.0	1227.3	2.2983	7.9935	75 @ 240F	
55-1	1206.5	688.7	1216.4	2.2863	8.4733	55 @ 240F	
55-2	1198.8	681.1	1207.9	2.2756	8.9021	55 @ 240F	
50-1	1189.7	678.5	1201.1	2.2765	8.8670	50 @ 240F	
50-2	1187.9	676.3	1205.7	2.2439	10.1737	50 @ 240F	
50-3	1216.3	694.0	1227.6	2.2794	8.7501	50 @ 240F	
45-1	1162.5	661.5	1172.5	2.2750	8.9291	50 @ 240F	
45-2	1217.0	693.7	1227.2	2.2812	8.6805	50 @ 240F	
45-3	1173.9	671.6	1193.9	2.2476	10.0257	50 @ 240F	

AK-Surface Mix w/Rouse GF-80A (4" pills) Project: P-150
(compacted at 265 F unless otherwise noted)

Pill #	OD	Sat.	SSD	Spec. Grav. (Bulk)	% Air Voids	Compaction (# Blows)	Test Performed on Sample
1 am	1202.0	697.5	1202.6	2.3797	3.8106	PLANT MADE	
2 am	1200.1	697.3	1200.6	2.3845	3.6191	PLANT MADE	
3 am	1199.5	695.7	1200.5	2.3762	3.9536	PLANT MADE	
4 am	1201.1	694.9	1201.9	2.3690	4.2428	PLANT MADE	
5 am	1204.3	696.3	1205.3	2.3660	4.3649	PLANT MADE	
1 noon	1201.7	694.1	1202.4	2.3642	4.7863	PLANT MADE	RES. MOD. (32F)
2 noon	1202.3	693.5	1203.9	2.3556	5.1308	PLANT MADE	RES. MOD. (77F)
3 noon	1204.6	694.6	1205.4	2.3583	5.0237	PLANT MADE	RES. MOD. (104F)
4 noon	1202.6	694.5	1203.4	2.3631	4.8274	PLANT MADE	
1 (7-14)	1200.2	691.4	1201.0	2.3552	5.0330	PLANT MADE	RES. MOD. (32F)
2 (7-14)	1174.9	680.7	1175.5	2.3745	4.2542	PLANT MADE	RES. MOD. (77F)
3 (7-14)	1166.0	674.7	1166.5	2.3709	4.3999	PLANT MADE	RES. MOD. (104F)
1 (2:00)	1199.9	697.3	1200.4	2.3850	3.9850	PLANT MADE	RES. MOD. (32F)
2 (2:00)	1199.7	696.8	1200.4	2.3822	4.0963	PLANT MADE	RES. MOD. (77F)
3 (2:00)	1197.2	694.7	1197.9	2.3792	4.2201	PLANT MADE	RES. MOD. (104F)
K1	1202.1	691.2	1203.0	2.3488	5.4441	75	RES. MOD. (77F)
K2	1199.2	689.2	1200.0	2.3477	5.4875	75	RES. MOD. (77F)
K3	1104.3	636.8	1105.6	2.3556	5.1695	75	RES. MOD. (77F)
K4	1208.4	695.4	1209.4	2.3510	5.3554	75	STABILITY
K5	1203.2	692.6	1204.8	2.3491	5.4315	75	RES. MOD. (104F)
K6	1200.3	693.3	1201.3	2.3628	4.8794	75	RES. MOD. (104F)
K7	1193.2	686.4	1194.3	2.3493	5.4235	75	STABILITY
K8	1202.5	692.7	1203.9	2.3523	5.3016	75	STABILITY
K9	1230.7	708.7	1231.9	2.3523	5.3037	75	RES. MOD. (32F)

AK-Surface Mix w/Rouse GF-80A (4" pills) Continued

Pill #	OD	Sat.	SSD	Spec. Grav. (Bulk)	% Air Voids	Compaction (# Blows)	Test Performed on Sample
11/12 1	1212	697.4	1213.1	2.3502	5.3863	75	RES. MOD. (32F)
11/12 2	1162.7	669.5	1163.8	2.3522	5.3053	75	RES. MOD. (32F)
11/12 3	1220.2	700.8	1221.5	2.3434	5.6609	75	RES. MOD. (104F)
11/12 4	1181.5	679.6	1184.1	2.3419	5.7197	75	
11/12 5	1195.5	687.4	1199.2	2.3359	5.9632	75	
11/12 6	1194.6	688.5	1196.8	2.3502	5.3870	75	
11/12 7	1166.8	673.9	1169	2.3567	5.1250	75	
H1	1202.7	688.5	1208.4	2.3133	7.0952	50	
H2	1205.4	689.0	1209.5	2.3159	6.9940	50	TSR (DRY)
H3	1204.4	687.7	1207.3	2.3179	6.9102	50	TSR (SAT.)
I1	1203.3	688.9	1207.0	2.3225	6.7259	50	TSR (DRY)
I2	1201.8	686.7	1204.8	2.3196	6.8422	50	
I3	1206.7	692.0	1211.1	2.3246	6.6426	50	TSR (DRY)
I4	1203.2	689.5	1207.6	2.3223	6.7337	50	TSR (SAT.)
I5	1206.3	691.1	1210.0	2.3247	6.6375	50	TSR (SAT.)
I6	1200.7	687.4	1204.7	2.3211	6.7835	50	
L1	1251.6	715.9	1255.3	2.3204	6.5879	50	
L2	1209.6	691.5	1212.9	2.3199	6.6060	50	TSR (DRY)
L3	1201.9	688.2	1206.3	2.3198	6.6094	50	TSR (SAT.)
L4	1200.3	684.0	1205.1	2.3034	7.2707	50	
B1	1153.9	662.8	1154.7	2.3458	5.6774	70	PRACTICE (Mr)
B2	1197.1	681.2	1200.3	2.3061	7.2736	70	
B3	1206.2	691.7	1207.5	2.3385	5.9709	70	PRACTICE (Mr)
C1	1204.3	689.4	1206.7	2.3280	6.3913	65	
C2	1201.2	686.9	1204.6	2.3203	6.7044	65	
C3	1194.0	683.4	1196.4	2.3275	6.4139	65	
D1	1211.6	694.5	1216.8	2.3197	6.7254	60	
D2	1195.2	684.2	1198.5	2.3239	6.5567	60	
D3	1208.6	691.6	1211.9	2.3229	6.5987	60	
D4	1203.3	689.0	1206.4	2.3257	6.4871	60	
D5	1204.6	689.1	1202.5	2.3463	5.6567	60	
D6	1210.5	693.4	1213.3	2.3283	6.3799	60	

AK-Surface Mix w/Rouse GF-80A (4" pills) Continued

Pill #	OD	Sat.	SSD	Spec. Grav. (Bulk)	% Air Voids	Compaction (# Blows)	Test Performed on Sample
E1	1209.8	694.1	1212.2	2.3351	6.1089	65	
E2	1192.9	683.6	1195.4	2.3308	6.2809	65	
E3	1201.6	690.7	1203.9	2.3414	5.8550	65	
E4	1211.3	694.5	1215.0	2.3272	6.4260	65	
E5	1210.0	693.2	1213.7	2.3247	6.5264	65	
E6	1206.3	688.3	1219.0	2.2730	8.6033	65	
F1	1197.3	686.3	1199.3	2.3339	6.2683	60	
F2	1197.7	686.7	1199.5	2.3356	6.2005	60	
F3	1210.3	692.4	1213.4	2.3230	6.7055	60	
G1	1198.8	688.0	1202.8	2.3287	6.4791	55	
G2	1197.3	684.0	1201.5	2.3136	7.0834	55	
G3	1199.8	687.2	1204.0	2.3216	6.7633	55	
J1	1201.1	688.0	1204.8	2.3241	6.6623	45	
J2	1205.2	687.2	1214.1	2.2873	8.1389	45	
J3	1198.5	686.6	1204.3	2.3150	7.0262	45	
J4	1197.5	682.1	1206.3	2.2844	8.2557	45	

APPENDIX B3 - Mixture Analysis Data

ASTM D 4887: Effect of Moisture on Asphalt Concrete Paving Mixtures

AK Surface Mix w/ 7.5% Rouse GF-80A

PROJECT: P-150 TECH: R. Bosley an P. Massie

DATE: 10-1-93 COMPACTION: 50 blows at 265 F

SAMPLE			H2	I1	I3	L2	H3	I4	L3
Diameter		D	4	4	4	4	4	4	4
Thickness		t	2.5885	2.5675	2.5735	2.5920	2.5815	2.5755	2.5625
Dry mass in Air		A	1205.4	1203.3	1206.7	1209.8	1204.4	1203.2	1201.9
SSD mass		B	1209.5	1207.0	1211.1	1212.9	1207.3	1207.6	1206.3
Mass in Water		C	689.0	686.9	692.0	691.5	687.7	889.5	688.2
Volume	(B-C)	E	520.5	518.1	519.1	521.4	519.6	518.1	518.1
Bulk Sp Gravity	(A/E)	F	2.316	2.320	2.325	2.320	2.318	2.322	2.320
Max Sp Gravity		G	2.490	2.490	2.490	2.484	2.490	2.490	2.484
% Air Voids	(100(G-F)/G)	H	6.99	6.84	6.64	6.61	6.91	6.73	6.81
Vol Air Voids	(HE/100)	I	36.39	35.46	34.48	34.45	35.91	34.89	34.25
Load		P	2100	2390	2300	2160			
SATURATED									
SSD mass		B'					1229.2	1227.1	1225.8
Mass in Water		C'					712.3	712.2	708.3
Volume	(B'-C')	E'					516.9	514.9	517.5
Vol Abs Water	(B'-A)	J'					24.8	23.9	23.9
% Saturation	(100J'/I)						69.06	88.49	69.79
% Swell	(100(E'-E)/E)						-0.5196	-0.6176	-0.1158
CONDITIONED									
Thickness		t"					2.5819	2.5936	2.5719
SSD mass		B"					1238.8	1236.2	1233.7
Mass in Water		C"					716.0	714.9	713.0
Volume	(B"-C")	E"					522.8	521.3	520.7
Vol Abs Water	(B"-A)	J"					34.4	33.0	31.8
% Saturation	(100J"/I)						95.79	94.57	92.85
% Swell	(100(E"-E)/E)						0.6159	0.6176	0.5018
Load		P"					1900	1975	1950
Dry Strength	2P/(3.14tD)	Std	129.12	146.15	142.24	133.86			
Avg. Dry Strength				138.34					
Wet Strength	2P"/(3.14t"D)	Stm					117.12	121.19	120.67
Avg. Dry Strength								138.34	
TSR							84.66	87.61	87.23
AVERAGE TSR (KTC lab compacted using 35 blows)									86.50%
AVERAGE TSR (Plant compacted using 27 blows)									71.00%

ASTM D 4867: Effect of Moisture on Asphalt Concrete Paving Mixtures

Regular AK-Surface Mix

PROJECT: P-150 TECH: R. Bosley and P. Massie

DATE: 10-8-93 COMPACTION: 50 blo s at 265 F

SAMPLE			N8	O2	N3	O3	N1	N4
Diameter		D	4	4	4	4	4	4
Thickness		t	2.5850	2.5665	2.5750	2.6000	2.5660	2.5525
Dry mass in Air		A	1206.0	1198.9	1200.1	1214.6	1201.1	1199.7
SSD mass		B	1207.9	1200.8	1202.0	1216.8	1204.0	1201.2
Mass in Water		C	687.3	684.2	665.3	693.3	685.7	684.4
Volume	(B-C)	E	520.6	516.6	516.7	523.5	518.3	516.8
Bulk Sp Gravity	(A/E)	F	2.317	2.321	2.323	2.321	2.317	2.321
Max Sp Gravity		G	2.494	2.494	2.494	2.494	2.494	2.494
% Air Voids	(100(G-F)/G)	H	7.11	6.95	6.87	6.96	7.08	6.92
Vol Air Voids	(HE/100)	I	37.04	35.89	35.51	36.41	36.70	35.77
Load		P	2385	2290	2325			
SATURATED								
SSD mass		B'				1240.8	1225.6	1223.0
Mass in Water		C'				717.4	707.6	706.2
Volume	(B'-C')	E'				523.4	518.0	516.8
Vol Abs Water	(B'-A)	J'				26.0	24.5	23.3
% Saturation	(100J'/I)					71.41	66.75	65.15
% Swell	(100(E'-E)/E)					-0.0191	-0.0579	-0.0000
CONDITIONED								
Thickness		t"				2.5978	2.5840	2.5811
SSD mass		B"				1244.9	1229.0	1228.3
Mass in Water		C"				721.2	710.6	710.1
Volume	(B"-C")	E"				523.7	518.4	518.2
Vol Abs Water	(B"-A)	J"				30.1	27.9	28.6
% Saturation	(100J"/I)					82.67	78.01	79.97
% Swell	(100(E"-E)/E)					0.0382	0.0193	0.2709
Load		P"				1910	2200	2010
Dry Strength	2P/(3.14tD)	Std	146.64	142.01	143.70			
Avg. Dry Strength				144.18				
Wet Strength	2P"/(3.14t"D)	Stm				117.02	135.50	124.91
Avg. Dry Strength							144.18	
TSR						81.16	93.98	86.63
AVERAGE TSR (KTC lab compacted using 35 blows)								87.26%
AVERAGE TSR (Plant compacted using 27 blows)								81.00%

Marshall Stability and Flow

AK Surface

Sample #	Corrected Stability (lbs)	Flow (1/100")
1	2225	8.5
2	2336	9.5
3	2352	9.5
Average	2304	9.2

AK Surface w/GF-80A

Sample #	Corrected Stability (lbs)	Flow (1/100")
K4	2512	10.0
K7	2416	9.5
K8	2703	11.0
Average	2544	10.2

APPENDIX B4 - Mixture Design Data Generated by KTC

Summary of Mix Design Data KY-421

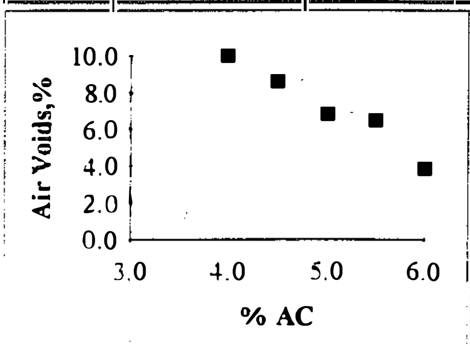
Material

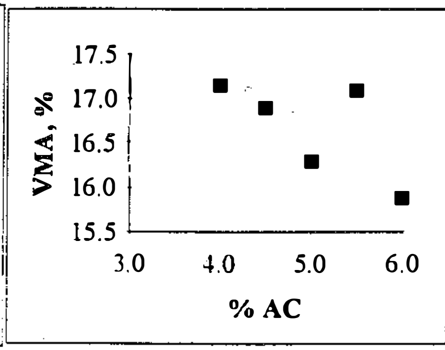
Aggregate	**Binder**
1. Nugent #8	AC-20 Ashland
2. Harrod LSS	7.5% Rouse GF-80
3. Nugent NS	(by weight of total binder)
4. 1/4" Chips	

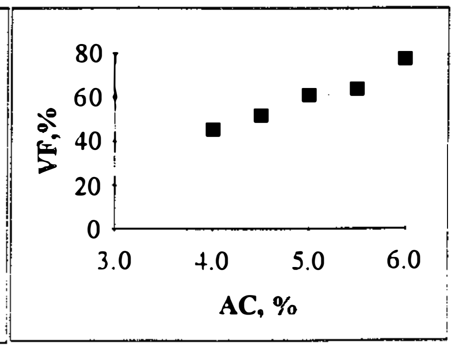
Optimum %AC = 5.4%

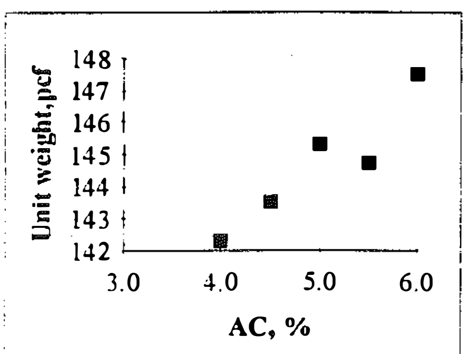
AC.%	Theoretical S.G.	Bulk S.G.	Air Voids.%	VMA.%
4.0	2.534	2.280	10.0	17.2
4.5	2.515	2.299	8.6	16.9
5.0	2.496	2.328	6.8	16.3
5.5	2.478	2.318	6.5	17.1
6.0	2.460	2.364	3.9	15.9

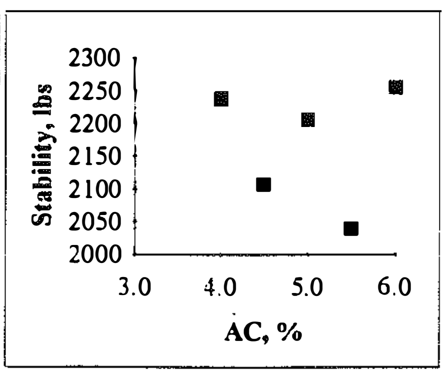
VF.%	Unit Weight	Stability. lbs	Flow(0.01in)
45	142.3	2238	8
52	143.5	2107	7
61	145.3	2206	8
64	144.7	2040	7
77	147.5	2254	7

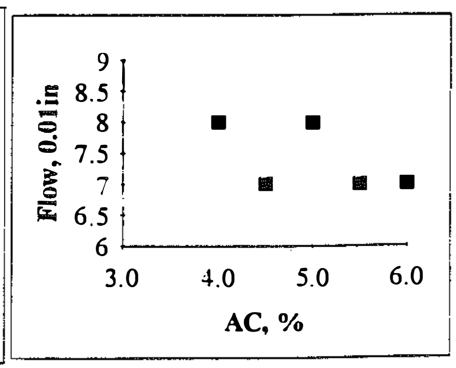












APPENDIX B5 - Mixture Design Data Generated by the Contractor

GRADATION COMBINATION PROGRAM

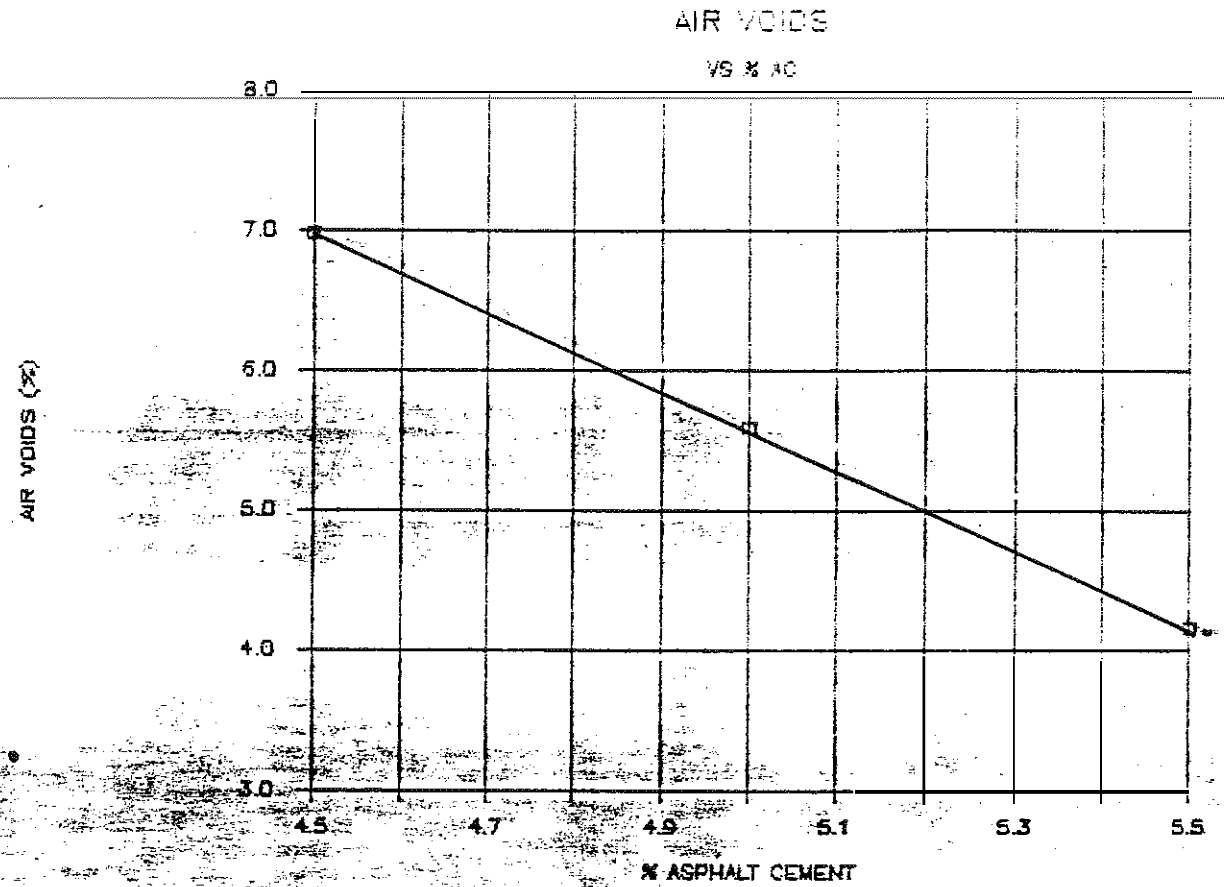
DATE: 5-28-93

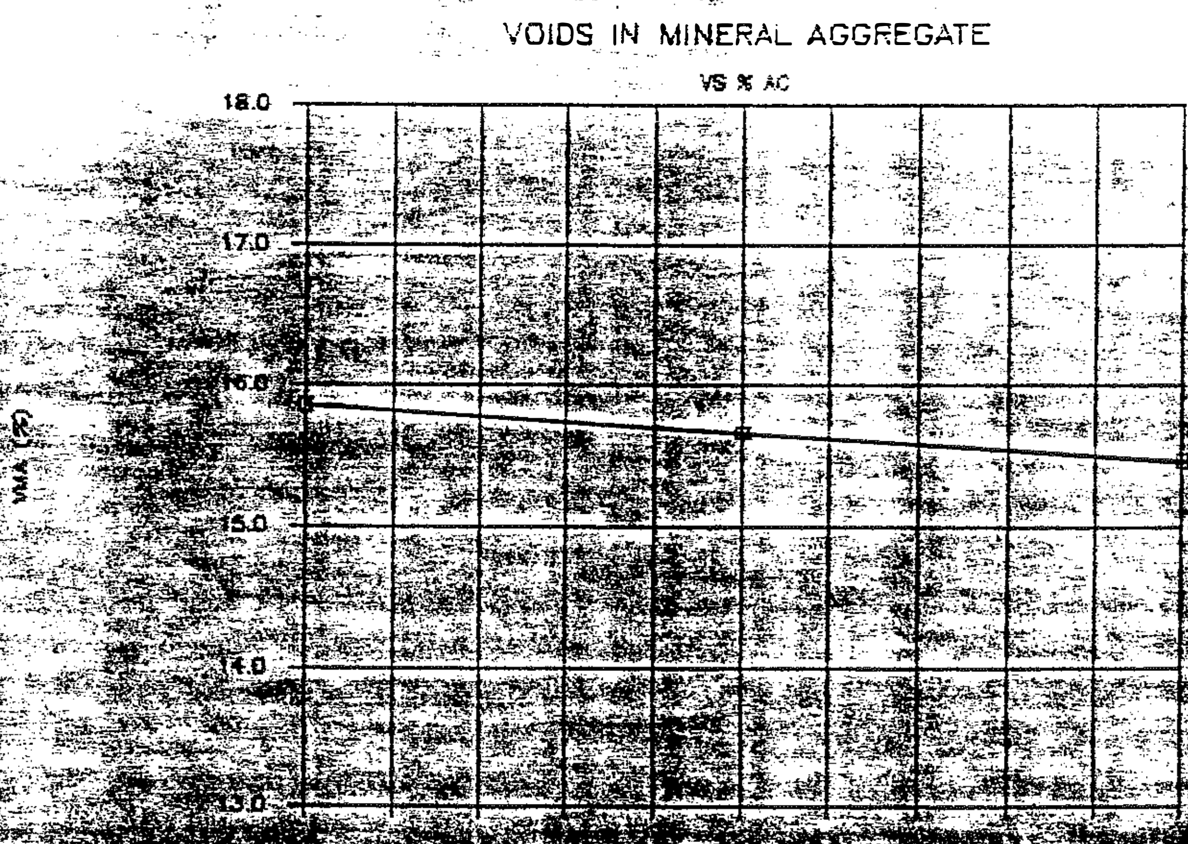
PROJECT: CLASS AK SURFACE/ THORNHILL BYPASS

AGGREGATE TYPES:

(1)-	NUGENT #8	(BIN1 %):	42.0	SIEVES	% PASS	CUMULAT. % RETAIN.	MASTER (LOWER)	RANGE (UPPER)	JMF SET @
(2)-	HARROD LSS	(BIN2 %):	23.0	1/2"-	100.0	0.0	100	100	100
				3/8"-	95.0	5.0	75	97	92
(3)-	NUGENT NS	(BIN3 %):	19.0	#4-	65.8	34.2	48	72	66
				#8-	39.8	60.2	30	54	40
(4)-	NUGENT 1/4"CHIPS	(BIN4 %):	16.0	#16-	27.5	72.5	18	40	28
				#30-	18.3	81.7	9	28	19
(5)-		(BIN5 %):	0.0	#50-	9.4	90.6	5	18	10
				#100-	5.4	0.0	2	10	6
(6)-		(BIN6 %):	0.0	#200-	4.2	95.8	1	5	4.5
(7)		(BIN7 %):	0.0						

SIEVE SIZE	AGG. (1) % PASS	AGG. (1) BIN % 42.0	AGG. (2) % PASS	AGG. (2) BIN % 23.0	AGG. (3) % PASS	AGG. (3) BIN % 19.0	AGG. (4) % PASS	AGG. (4) BIN % 16.0	AGG. (5) % PASS	AGG (5) BIN % 0.0	AGG. (6) % PASS	AGG. (6) BIN % 0.0
1/2"-	100.0	42.0	100.0	23.0	100.0	19.0	100.0	16.0	0.0	0.0	0.0	0.0
3/8"-	88.3	37.1	100.0	23.0	100.0	19.0	99.2	15.9	0.0	0.0	0.0	0.0
#4-	21.6	9.1	97.3	22.4	99.6	18.9	96.2	15.4	0.0	0.0	0.0	0.0
#8-	2.3	1.0	69.7	16.0	87.8	16.7	38.3	6.1	0.0	0.0	0.0	0.0
#16-	1.0	0.4	43.1	9.9	68.5	13.0	26.1	4.2	0.0	0.0	0.0	0.0
#30-	0.9	0.4	29.1	6.7	48.9	9.3	12.1	1.9	0.0	0.0	0.0	0.0
#50-	0.8	0.3	21.4	4.9	17.6	3.3	5.0	0.8	0.0	0.0	0.0	0.0
#100-	0.7	0.3	16.7	3.8	4.2	0.8	2.7	0.4	0.0	0.0	0.0	0.0
#200-	0.6	0.3	13.6	3.1	2.7	0.5	2.2	0.4	0.0	0.0	0.0	0.0


AIR VOIDS
VS % AC
8.0
7.0
6.0
5.0
4.0
3.0
AIR VOIDS (%)
4.5
4.7
4.9
5.1
5.3
5.5
% ASPHALT CEMENT


VOIDS IN MINERAL AGGREGATE
VS % AC
18.0
17.0
16.0
15.0
14.0
13.0
VMA (%)

VOIDS ANALYSIS

COMPACTIVE EFFORT: 75 (blows/side)
COMBINED BULK AGG. SP. GRAVITY(Gsb): 2.644
ASPHALT CEMENT SP. GRAVITY(Gb): 1.03

EFFECTIVE SPECIFIC GRAVITY(Gse): 2.686

AC (%)	SPEC. #	W/AIR (GRAMS)	W/WATER (GRAMS)	W/SSD (GRAMS)	BULK VOL.	BULK SP. GRAVITY	UNIT WEIGHT (pcf)	MAX. SP. GRAVITY	VOIDS (%)	VMA (%)	VFWA (%)	ABSORBED AC (%)	EFFECTIVE AC (%)
		(A)	(B)	(C)	(C-B)	A/(C-B) or (G)	(G*62.4)	(D)	100(D-G) / (D)	100 - (G)(100-AC) /Gsb	100(VMA-VOID) / VMA	100*Gb* (Gse-Gsb) /(GsbGse)	AC-ABS. (100-AC)
4.5	1	1182.0	680.0	1187.4	507.4	2.330	145.4	2.505	7.0	15.9	55.9		
	2	1182.2	680.3	1187.8	507.5	2.329	145.4	2.505	7.0	15.9	55.9		
	3	1181.8	679.6	1187.0	507.4	2.329	145.3	2.505	7.0	15.9	55.9		
AVE.						2.329	145.4		7.0	15.9	55.9	0.60	3.92
5.0	4	1187.9	686.2	1191.7	505.5	2.350	146.6	2.486	5.5	15.6	64.9		
	5	1185.4	684.1	1189.1	505.0	2.347	146.5	2.486	5.6	15.7	64.4		
	6	1188.9	685.3	1192.5	507.2	2.344	146.3	2.486	5.7	15.8	63.8		
AVE.						2.347	146.5		5.6	15.7	64.4	0.60	4.43
5.5	7	1195.1	692.3	1196.7	504.4	2.369	147.8	2.468	4.0	15.3	74.0		
	8	1194.0	690.2	1195.9	505.7	2.361	147.3	2.468	4.3	15.6	72.4		
AVE.						2.365	147.6		4.1	15.5	73.2	0.60	4.93

MAXIMUM SPECIFIC GRAVITY

ASPHALT CONTENT:	5.0	5.0
WEIGHT OF SAMPLE + CONTAINER:	3186.7	3188.1
WEIGHT OF CONTAINER:	1995.3	1995.3
WEIGHT OF SAMPLE (A):	1191.4	1192.8
CALIBRATION (D):	7234.8	7234.8
SUM (A+D):	8426.2	8427.6
FINAL WEIGHT (E):	7947.3	7949.3
DIFFERENCE (A+D-E):	478.9	478.3
VOLUME ABSORBED WATER (G):	0.9	1.0
CORRECTED DIFFERENCE (A+D-E+G):	479.8	479.3
MAXIMUM SPECIFIC GRAVITY : (A) / (A+D-E+G)	2.483	2.489

AVERAGE MAXIMUM SPECIFIC GRAVITY(Gmm): 2.486

EFFECTIVE SPECIFIC GRAVITY(Gse): 2.686

CALCULATED MAXIMUM SPECIFIC GRAVITY:

% AC	MAX. SP. GRAVITY
4.5	2.505
5.0	2.486
5.5	2.468

MARSHALL STABILITY FLOW ANALYSIS

ASPHALT CEMENT (%)	SPECIMEN #	SPECIMEN HEIGHT (inches)	CORRECTION FACTOR	UNCORRECTED MARSHALL STABILITY (lbs.)	CORRECTED MARSHALL STABILITY (lbs.)	FLOW (inches)
4.5	1	2.512	0.99	2090	2072	0.070
	2	2.514	0.99	2230	2208	0.070
	3	2.511	0.99	2090	2074	0.070
AVERAGE					2118	0.070
5.0	4	2.487	1.01	2070	2086	0.077
	5	2.487	1.01	2050	2066	0.074
	6	2.481	1.01	2090	2115	0.070
AVERAGE					2089	0.074
5.5	7	2.464	1.02	1980	2026	0.074
	8	2.474	1.02	2110	2145	0.080
AVERAGE					2086	0.077
0.0	0	0.000	4.94	0	0	0.000
	0	0.000	4.94	0	0	0.000
	0	0.000	4.94	0	0	0.000
AVERAGE					0	0.000

Contractor: H. G. Mays Corp. @ Frankfort, KY

Project: Franklin Co., US 421 (Thornhill Bypass)

GRADATION COMBINATION PROGRAM

DATE: [illegible]/28/93

PROJECT: CLASS AK SURFACE THORNHILL BYPASS

AGGREGATE TYPES:

(1) -	NUGENT #8	(BIN1 %):	42.0 %
(2) -	HARROD LSS	(BIN2 %):	23.0 %
(3) -	NUGENT NS	(BIN3 %):	19.0 %
(4) -	NUGENT 1/4"CHIPS (crushed gravel sand)	(BIN4 %):	16.0 %
(5) -		(BIN5 %):	0.0
(6) -		(BIN6 %):	0.0
(7)		(BIN7 %):	0.0

Job Mix Formula

SIEVES	% PASS	CUMULAT. % RETAIN.	MASTER (LOWER)	RANGE (UPPER)	JMF SET ?	Wet Sieve Analysis
1/2"-	100.0	0.0	100	100	100	100
3/8"-	95.0	5.0	75	97	92	92
#4-	65.8	34.2	48	72	66	66
#8-	39.8	60.2	30	54	40	39
#16-	27.5	72.5	19	40	28	27
#30-	18.3	81.7	9	28	19	18
#50-	9.4	90.6	5	18	10	9
#100-	5.4	0.0	2	10	6	5
#200-	4.2	95.8	1	5	4.5	2.5

SIEVE SIZE	Nugent #8 AGG. (1) % PASS	AGG. (1) BIN % 42.0	Harrod Limestone Sand AGG. (2) % PASS	AGG. (2) BIN % 23.0	Nugent natural sand AGG. (3) % PASS	AGG. (3) BIN % 19.0	Nugent Crushed Gravel Sand AGG. (4) % PASS	AGG. (4) BIN % 16.0	AGG. (5) % PASS	AGG (5) BIN % 0.0	AGG. (6) % PASS	AGG. (6) BIN % 0.0
1/2"-	100.0	42.0	100.0	23.0	100.0	19.0	100.0	16.0	0.0	0.0	0.0	0.0
3/8"-	98.3	37.1	100.0	23.0	100.0	19.0	99.2	15.9	0.0	0.0	0.0	0.0
#4-	21.6	9.1	97.3	22.4	99.6	18.9	96.2	15.4	0.0	0.0	0.0	0.0
#8-	2.3	1.0	69.7	16.0	87.8	16.7	38.3	6.1	0.0	0.0	0.0	0.0
#16-	1.0	0.4	43.1	9.9	68.5	13.0	26.1	4.2	0.0	0.0	0.0	0.0
#30-	0.9	0.4	29.1	6.7	48.9	9.3	12.1	1.9	0.0	0.0	0.0	0.0
#50-	0.8	0.3	21.4	4.9	17.6	3.3	5.0	0.8	0.0	0.0	0.0	0.0
#100-	0.7	0.3	16.7	3.8	4.2	0.8	2.7	0.4	0.0	0.0	0.0	0.0
#200-	0.6	0.3	13.6	3.1	2.7	0.5	2.2	0.4	0.0	0.0	0.0	0.0

Design Mixture Properties of Conventional Class AK Surface

- Design Asphalt Content: 5.1 %
- Tensile Strength Retained (per KM 64-428): 82 % (without anti-stripping additive) ASTM-D = 4867
- Stability: 2680 lbs.
- Flow: 0.08 inches
- Air Voids: 4.3 %
- VMA: 14.8 %
- VFWA: 72 %
- Maximum Specific Gravity: 2.476
- Compaction: 75 blows (using Mechanical Hammer)
- Bulk Specific Gravity of Combined Aggregate: 2.642
- Specific Gravity of Asphalt Cement: 1.03

APPENDIX B6 - Mixture Quality Control / Quality Assurance

MEMORANDUM

TO: Files

FROM: Danny Young
Field Operations Section
Division of Materials

DATE: July 28, 1993

SUBJECT: Franklin County, SSP 037 0421 003-005 074 H
AK Surface Mixtures

Attached is information obtained juring field verification testing performed on plant produced material.

The information consists of volumetric analysis for the AK surface mixture containing Rubberized Asphalt Cement and the control mixture containing AC-20.

Also attached is data from the cores taken from the control strips which were constructed for the various mixtures and asphalt contents.

Each days production is listed with the values for testing by Materials Central Lab personnel and by the contractor when he performed Marshall testing. Also on file within the Field Operations Section is data from which the summary sheets were documented.

It should be noted that when extraction testing was performed in the MCL, evidence of the rubber fines were in the fine fractions of the aggregate. Also, the effluent contained rubber fines which shows that the rubber was not completely dissolved into the asphalt cement.

Samples were also obtained for testing on the Loaded Wheel Tester. At this point testing has not been completed.

DY:tc

JUL 29 1993

SUMMARY OF PLANT-PRODUCED BITUMINOUS MIXTURE'S PROPERTIES
(FVSUMFRM)

PROJ. # (FHWA) ______ UPN) (#211) SSP 037 0421 003-005 074 H

COUNTY FRANKLIN MIX TYPE AK SURFACE MIX ID # w/Rubberized f

SUPPLIER H.G. MAYS CORP. LOCATION FRANKFORT

DATE VERIFIED 7-13-93 AM VERIFIED BY MATERIALS CENTRAL LAB Personnel

RESULTS:

PROPERTY	MCL F/V	CONTR	ACCEPTABLE LIMITS	DESIGN
STAB., lbs.	2200	—	1800 (min.)	2150
FLOW, 0.01"	10	—	8-16	7
MSG	2.466	2.474		2.485
UW, PCF	147.0	148.8		145.5
AV, %	4.5	3.6	3.5-6.5	5.8
VMA, %	15.6	14.2	14.5 (min.)	16.4
TSR, %	—	—	65 (min.)	—
AC, %	5.2 (Extr.)	5.3 (back calc.)	5.0 — 5.6	5.3

GRADATION - P 200, % 5.5 OTHER SIGNIFICANT VALUES NACG

PAN #1 = 5.3% % AC by NACG using master calibration, % AC by extraction performed by the contractor: 5.3 and 5.1%.

REMARKS:

Design values based on Mix Design data provided by U.K. Research Personnel.

Limited Production of approximately 550 tons was performed at 5.3% AC. Based on values obtained at the contractors (air voids and % VMA of the plant produced mixture) the % AC was reduced to 5.1%.

This material was placed on the inside lane from the concrete section uphill to approximately the turn lanes at 421 & Schenkel lane.

MSG RPTD to DME 2.474 Confirmed ____ Revised Yes.

cc:

DME # - 5 COMPILED BY DY DATE 7/19/93

FILES RVD BY: DY ______ DW ______.

SUMMARY OF PLANT-PRODUCED BITUMINOUS MIXTURE'S PROPERTIES
(FVSUMFRM)

PROJ. # (FP-A) ____________ (UPN) (#211) SSP 037 0421 003-005 074 H

COUNTY FRANKLIN MIX TYPE AK Surface MIX ID # W/Rubberized AC

SUPPLIER H.G. Mays Corp. LOCATION FRANKFORT

DATE VERIFIED 7/13/88 PM VERIFIED BY MATERIALS CENTRAL LAB PERSONNEL

RESULTS:

PROPERTY	MCL F/V	CONTR	ACCEPTABLE LIMITS	DESIGN *
STAB., lbs.	2275	—	1800 (min)	2175
FLOW, 0.01"	9	—	8-16	7
MSG	2.491	2.483		2.493
UW, PCF	146.4	147.8		145.0
AV, %	5.8	4.6	3.5-6.5	6.5
VMA, %	15.7	15.0	14.5 (min.)	16.5
TSR, %	58	—	65 (min.)	—
AC, %	5.2 NACG	(5.1 back calc.)	4.8-5.4	5.1

GRADATION - P 200, % ________ OTHER SIGNIFICANT VALUES ________

% AC by NACG using master calibration.

REMARKS:

MSG was revised for 5.1% AC, also at this point a new control strip was constructed in order to establish a target for the 5.1% mixture which utilized rubberized asphalt cement.

* Design values based on Marshall data supplied by UK Research Personnel.

MSG RPTD to DME 2.483 Confirmed ____ Revised Yes

cc:

DME #- 5 COMPILED BY DY DATE ________

FILES RVD BY: DY ________ DW ________

SUMMARY OF PLANT-PRODUCED BITUMINOUS MIXTURE'S PROPERTIES
(FVSUMFRM)

PROJ. = (FHWA) ____________ (UPN) (#211) SSP 037 0421 003-005 074 H

COUNTY Franklin MIX TYPE AK Surface MIX ID # w/Rubberized AC

SUPPLIER H.G. Mays Corp LOCATION Frankfort

DATE VERIFIED 7-14-93 (AM & PM) VERIFIED BY Materials Central Lab Personnel

RESULTS:

PROPERTY	MCL F/V Pan #1	Contr. F/V Pan #1	ACCEPTABLE LIMITS	DESIGN *
STAB., lbs.	2375	–	1800 (min)	2175
FLOW, 0.01"	9	–	8-16	7
MSG	2.485	2.480		2.493
UW, PCF	147.5	147.9		145.0
AV, %	4.9	4.4	3.5-6.5	6.5
VMA, %	15.1	14.8	14.5 (min.)	16.5
TSR, %	71	–	65 (min.)	–
AC, %	5.2 NACG	–	4.8 – 5.4	5.1

GRADATION - P 200, % ______ OTHER SIGNIFICANT VALUES ______

% AC by NACG using master calibration. Extraction by contractor 5.1 and 5.1%.

REMARKS:

Both AM and PM samples were taken this date. As noted above the AM sample (pan #1) was compacted by both MCL and the Contractor for comparison purposes. Pan #2 (PM sample) results are on the attachment.

* Design data based on Mix Design supplied by UK Research Personnel.

MSG RPTD to DME 2.483 Confirmed ____ Revised ______.
cc:
DME #- 5 COMPILED BY DY DATE ______
FILES RVD BY: DY ______ DW ______.

SUMMARY OF PLANT-PRODUCED BITUMINOUS MIXTURE'S PROPERTIES
(FVSUMFRM)

PROJ. # (F-WA) ________ (CON) (#211) SSP 037 0421 003-005 074 H

COUNTY FRANKLIN MIX TYPE AK Surface MIX ID.# w/Rubberized AC

SUPPLIER H.G. MAYS CORP. LOCATION FRANKFORT

DATE VERIFIED 7/15/83 VERIFIED BY MATERIALS CENTRAL LAB PERSONNEL

RESULTS:

PROPERTY	F/V	ACCEPTABLE LIMITS	DESIGN *
STAB., lbs.	2150	1800 (min.)	2175
FLOW, 0.01"	11	8-16	7
MSG	2.484		2.493
UW, PCF	147.8		145.0
AV, %	4.6	3.5-6.5	6.5
VMA, %	14.9	14.5 (min.)	16.5
TSR, %	—	65 (min.)	—
AC, %	5.2 (EXTR)	4.8-5.4	5.1

GRADATION - P 200, % — OTHER SIGNIFICANT VALUES ________

REMARKS:

Extraction Results by contractor this date: 4.9 and 5.2%. P200 content by contractor testing 5.0 and 5.0%.
Final days production for mixture using Rubberized AC.
* Design data based on Mix Design supplied by UK Research Personnel.

MSG RPTD to DME 2.483 Confirmed ____ Revised ____.
cc:
DME #- 5 COMPILED BY DY DATE ________
FILES RVD BY: DY ________ DW ________.

SUMMARY OF PLANT-PRODUCED BITUMINOUS MIXTURE'S PROPERTIES
(FVSUMFRM)

PROJ. # (F-WA) ______ (-PN) (#211) SSP 037 0421 003-005 074 H

COUNTY FRANKLIN MIX TYPE AK Surface MIX ID # w/ AC-20

SUPPLIER H.G. MAYS Corp. LOCATION Frankfort

DATE VERIFIED 7/15/93 VERIFIED BY Materials Central Lab Personnel

RESULTS:

PROPERTY	F/V	ACCEPTABLE LIMITS	DESIGN
STAB., lbs.	2700	1800 (min.)	* 2675
FLOW, 0.01"	11	8-16	8
MSG	2.486		2.4
UW, PCF	150.7		148.1
AV, %	2.9	3.5-6.5	4.3
VMA, %	13.2	14.5 (min.)	14.8
TSR, %	81	65 (min.)	82
AC, %	5.4 (EXTR)	4.8-5.4	5.1

GRADATION - P 200, % 7.0 OTHER SIGNIFICANT VALUES

% AC by NACG using master calibration 5.5% for Pan #1.

REMARKS: *Design values from Marshall testing performed by MCL.

1st days production for mixture with AC-20.

% AC by NACG using 4" pills 4.9% using calibration performed by MCL.

The air voids and % VMA are below the minimum specified minimums. It should be noted that this sample was taken from the last load of material produced this date and so deviation in the production would be expected. A follow up verification will be performed on 7/16/93.

MSG RPTD to DME 2.486 Confirmed ____ Revised No.

CC:

DME #- 5 COMPILED BY DY DATE ______

FILES RVD BY: DY ______ DW ______.

- to confirm mixture properties prior to requiring adjustments if deemed necessary

SUMMAR· OF PLANT-PRODUCED BITUMINOUS MIXTURE'S PROPERTIES
(FVSUMFRM)

PROJ. # (FHWA) ____________ (CON) (#211) SSP 037 0421 003-005 074 H

COUNTY FRANKLIN MIX TYPE AK Surface MIX ID # W/AC-20

SUPPLIER H.G. Mays Corp. LOCATION Frankfort

DATE VERIFIED 7-16-93 VERIFIED BY MATERIALS CENTRAL LAB Personnel

RESULTS:

PROPERTY	F/V	ACCEPTABLE LIMITS	DESIGN *
STAB., lbs.	2400	1800 (min)	2675
FLOW, 0.01"	10	8-16	8
MSG	2.497		2.476
UW, PCF	148.8		148.1
AV, %	4.5	3.5-6.5	4.3
VMA, %	14.4	14.5 (min)	14.8
TSR, %	—	65 (min)	82
AC, %	5.2 (EXTR)	4.8-5.4	5.1

GRADATION – P 200, % 6.0 OTHER SIGNIFICANT VALUES ________

REMARKS:

*Design values from Marshall testing performed by MCL

% AC by extraction performed by contractor: 5.0 and 4.9%.

P200 content from testing by contractor 5.0 and 5.0%.

MSG RPTD to DME 2.497 Confirmed ____ Revised No.

cc:

DME #- 5 COMPILED BY DY DATE ________

FILES RVD BY: DY ________ DW ________

FRANKLIN Co.
(#211) SSP 037 ~~[illegible]~~ 003-005 0-
AK Surface

BITUMINOUS MIXTURES FIELD VERIFICATION REPORT
COMMENTS & RECOMMENDATIONS

Attached are results of core density testing performed by MCL. The cores were supplied by the Resident Engineer. They were taken from the control strips which were constructed on the project.

Core #	5.3% Rubberized AC (2.474 solid density) 154.4		5.1% Rubberized AC (2.483 solid density) 154.9		5.1% AC-20 (2.483 solid density) 154.9	
	5.1-1	(142.6)	5.3-1	(143.7)	1	(146.3)
	5.1-2	(142.2)	5.3-2	(146.3)	2	(146.2)
	5.1-3	(143.7)	5.3-3	(145.8)	3	(146.4)
	5.1-4	(144.7)	5.3-4	(144.7)	4	(142.9)
		143.3 pcf average		145.1 pcf average	5	(144.8)
						145.3 pcf average

$\frac{143.3}{154.4}$ = 92.5% of solid (93%)

$\frac{145.1}{154.9}$ = 93.97% of Solid (94%)

$\frac{145.3}{154.9}$ = 93.8% of Soli (94%)

The actual location from which the nuclear density testing was performed and subsequent coring locations are on file at the Resident Engineer's office.

:34-404 (2-A)

DRUM

CONTRACTORS JOB-MIX FORMULA & ASPHALT PLANT ([redacted]) MIX DESIGN

3-3-

Ident No. 00930 2650

County Franklin 114

INSPECTOR SSN 317-26-2988 Name R. Simmons Crew Contr.

DATE SAMPLED 02-08-93 Sample Sequence No. 4

TYPE OF INSPECTION INF Original Ident

PRODUCER NO. P182001 Name Frankfort Materials Loc Frankfort

MATERIAL CODE 050125 Description Class AK Surface (Exp.)

INSPECTED QUANTITY 9999999.9 Units Tons

RESPONSIBLE LOC C5 LAB 0C5 Name Materials Central Lab

Detail Test ☒ Distribution ~~ ~~

Proj Code	Project Number	QUANTITY	DATE ASSIGNED
022236	SSP 037 C421 003-005 074H (#241)	000000000.0	03-25-9

DATE REC. 02-10-93 DATE COM. PASS/FAIL UNPR Reason

	Aggregate Prod. CD	Prod. Name	Mat'l CD	Size	Aggregate
Coarse	P002302	Nugent Sand & Gravel	001008	Grav. #8's	42.0
Coarse					.
Fine	P002302	Nugent Sand & Gravel	001CGS	Grav. mfg. sd.	16.0
Fine	P002302	Nugent Sand & Gravel	001BFA	n. sd.	19.0
Filler	P005101	Harrod Stone	001BFA	lssand	23.0

Screens-Scalper

Sieve Size	WET SIEVE Job-Mix	Extractions Mix Gradations				Rev JMF	JMF/Specs
1/2	100						
3/8	92						
4	66						
8	40						
16	28						
30	19						
50	10						
100	6						
200	4.5						
F.M.							

Mix Approval Data

Approved Asph Cont 05.1 %

Target Mix Temp 300

Mix Time (Dry) 0 (Wet)

Plant Data

Aggr/Batch Lbs Asph/Batch (Lbs.)

Total Batch Wt Lbs Gals of Asph/Batch (Fluidometer)

Approved by DME Larry E. Epley Date

Approved by MTL AKM Date March 25, 1993

Approved ☒ As Proposed ☐ With Changes ☐ Disapproved (See Remarks)

% Bin 4 . Bin 3 . Bin 2 . Bin 1 . Filler . Totals

Pounds

Acc Wt

Asphalt Data

Temp. Bit. Mix AC-20 Ashland @ Louisville

Type 030102 Producer P150901 Bitumen (By Design) 05.1 % Additive ~~.~~

Extraction Tests . . . . Cold Feed Data % Natural Sand

Submitted By R. Simmons Project Engineer

Set up by Tech. Date MTLS Rep.

Goo. attached instructions. Plant Inspector R. Simmons, R. Casey, It should be noted that the design asphalt content is established for this particular combination of materials and project characteristics and should not be used on other projects without evaluating the materials' source(s), gradation, and the project conditions.

"Minor-change" tolerances are permitted on the + #4 fraction of the mixture only. Adjustments on the - #4 fraction of the mixture, in particular the - #200 fraction, are contingent upon plant-produced mixture properties indicating adequate air voids. Bituminous mixtures of this nature have a potential for flushing and/or rutting. Significant revisions may require a new lab design. The design asphalt content is for the submitted JMF gradation. Deviations from the materials furnished the laboratory or in the actual project gradation may require an adjustment in the design asphalt content.

* Special Note for Bituminous Concrete Surface, Class AK, applies (75 blows).

* Compaction control strip from Special Note for Bituminous Concrete Surface, Class AK, applies.

* Laboratory Marshall density: 148.1 PCF @ 5.1 % AC.
  Laboratory maximum specific gravity: 2.476 @ 5.1 % AC.
  Laboratory solid density: 154.5 PCF @ 5.1 % AC.

* Special Note for Acceptance of Bituminous Mixtures applies.

* Job-mix formula (JMF) is based on wet-sieve analysis.

* All mix design values are from a Materials Central Lab (MCL) design.

* Contact Materials Central Lab (MCL) prior to the start of production.

* Cold feed checks are required twice daily.

* One sample consisting of the + #4 combined aggregate (from either all extractions, hot bin samples, or combining belt samples) to represent the job will be needed. This sample shall be submitted to the Materials Central Lab (MCL), Aggregate Section, for Insoluble Residue and/or Percent Crushed testing.

* It is recommended that mix design properties of plant-produced material be monitored by District personnel. The following information should be used during the performance of field verifications:

  Bulk Specific Gravity of Aggregate = 2.642

	Marshalls	TSR's
Specimen Weight (grams):	1205	1165
No. of blows:	75	27

* Although the percentage of voids-in-mineral aggregate (% VMA) is slightly low, the value is in reasonably close ~~conformance with the specifications.~~

  The % VMA of this mixture is "borderline" at best. In fact, using some combinations of aggregate specific gravity values as tested by MCL results in unacceptable % VMA. For this reason, the contractor is strongly urged to maintain close control of the dust content of this mixture during production. Field verification analyses of this mixture may yield low % VMA values, thereby requiring some sort of mixture modification.

* The contractor submitted three Marshall specimens and one maximum specific gravity (MSG) sample to MCL for analysis, with the following results:

UW = 147.1 pcf	Stab. = 2305 lbf	Flow = 0.09 "
% AV = 5.1	MSG = 2.484	% AC = 5.1
% VFWA = 67	% VMA = 15.3	% Eff. AC = 4.5
	% Abs. AC (Mix) = 0.63	Comp. = 75 blows

C64-711

MARSHALL TEST

Rev. 12-9-

D. No.	00930 2651	County	FRANKLIN
INSPECTOR SSN	317-26-2988	Name	R. Simmons Crew CONTR.
DATE SAMPLED	02-08-93	Sample Sequence No.	14
TYPE OF INSPECTION	INF	Original Ident	
PRODUCER NO./SUPP. NO.	P1182001	Name	Frankfort Materials Loc Frankfort
MATERIAL CODE	050125	Description	CLASS AK SURFACE (EXP.)
INSPECTED QUANTITY	9999999.9	Units	TONS
LOT NO.	00930265?0		
Sampled From	BIT PLANT STOCKPILES		
RESPONSIBLE LOC	05 LAB 000	Name	MATERIALS CENTRAL LAB
Detail Test	☒	Distribution	

Proj Code	Project Number	QUANTITY	DATE ASSIGNED
022236	SSP 037 0421 003-005 074H (#211)	00000000.0	03-25-9
		.	- -

DATE REC. 02-10-93 DATE COM. 03-25-93

PASS/FAIL COMP Reason

Costs

NO CHARGE

Design Results for CL AK SURF EXP-US421

Unit Weight PCF	148.1	Stability Lbs.	2680	Flow Ins.	0.08
Voids in Mix %	04.3	Max. Spec. Gr.	2.476	Asph. Content %	05.1
Sand Equivalent	80	VMA	14.8	Eff. AC%	04.6
UFWA	072	ABS.AC Mix	0.50	Compaction	075

INSTRUCTIONS

LABORATORY MIX DESIGN CRITERIA: STABILITY → 1800 LBF (MINIMUM); FLOW → 0.08" – 0.16"; % AIR VOIDS → 4.0 ± 1.0; % VMA → 15.0 (MINIMUM); % TSR → 70 (MINIMUM). TSR WITHOUT ADDITI = 82%; no additive required. D/A = 0.9. Class AK, Acceptance notes apply. A mix design values are from MCL design. % Crushed (1 or more) = 98; % Crush (2 or more) = 92, and Insoluble Residue = 38% on gravel #8's. Bulk specific gravity of aggregate = 2.642. Although % VMA is slightly low, value is in reasonably close conformance with specifications. % VMA of this mix is "borderline" at best. Contractor is strongly urged to maintain close control

Remarks: of dust content. Field verification analyses may

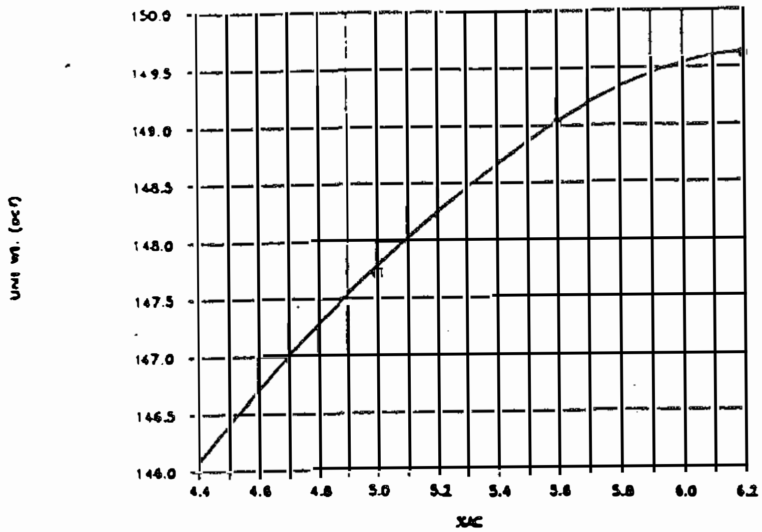
Copies: R. Simmons, R. Casey, B. Roach, Files

KENTUCKY DEPARTMENT OF HIGHWAYS
Laboratory Mix Design Report

Mix Identification: # 14, Franklin Class AK Surface (Exp.)
Project Number: SSP 037 0421 003-005 074H (#211)
Compaction: 75 blows

Contractor: Frankfort Materials
@ Frankfort

Unit Wt. vs. %AC



Design Results

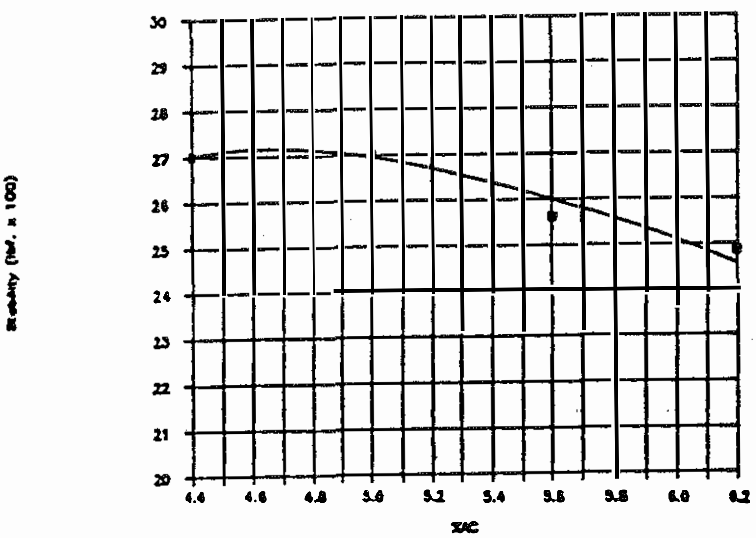
Asphalt Content, % 5.1

Unit Weight, pcf 148.1

Stability, lbf 2680

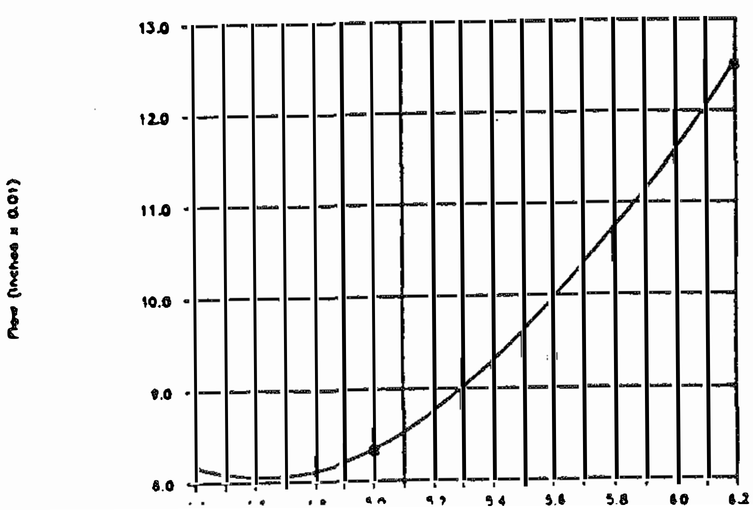
Flow, ins. 0.08

Stability vs. %AC

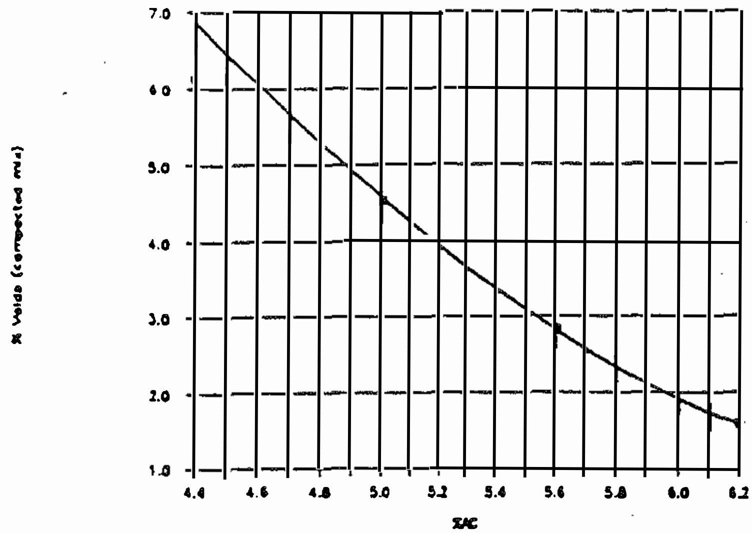


Remarks:

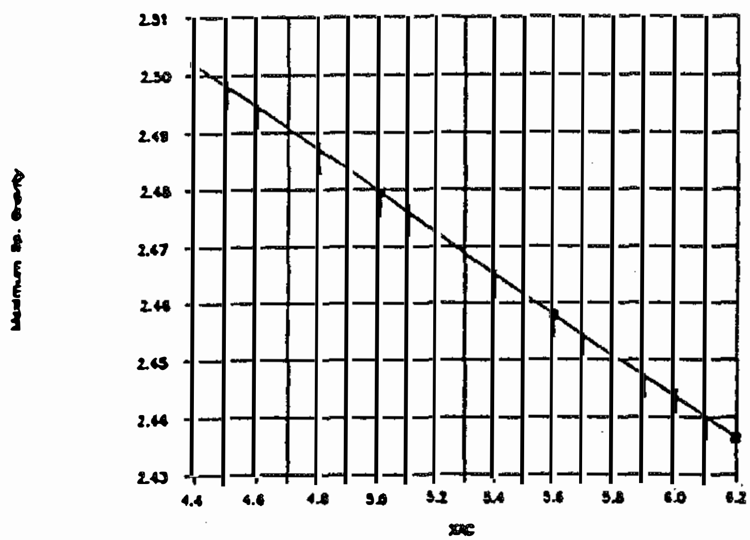
Flow vs. %AC



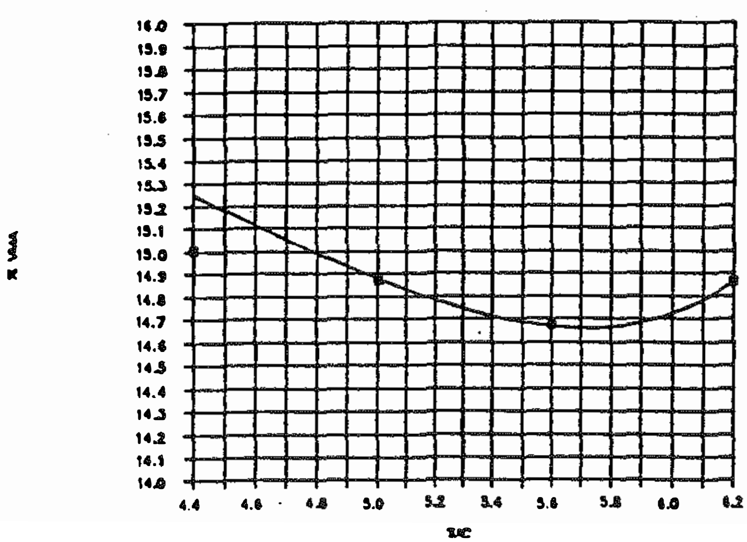
% Voids vs. %AC



Max Sp. Grav. vs. %AC



%VMA vs. %AC



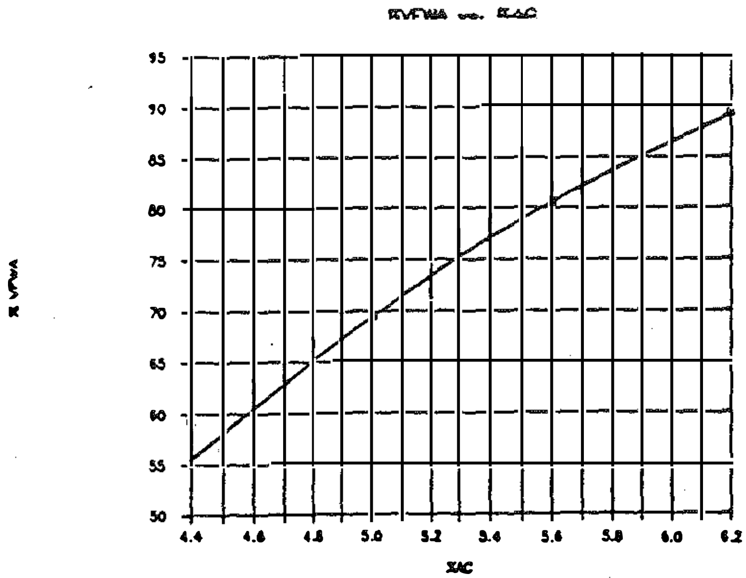
Design Results

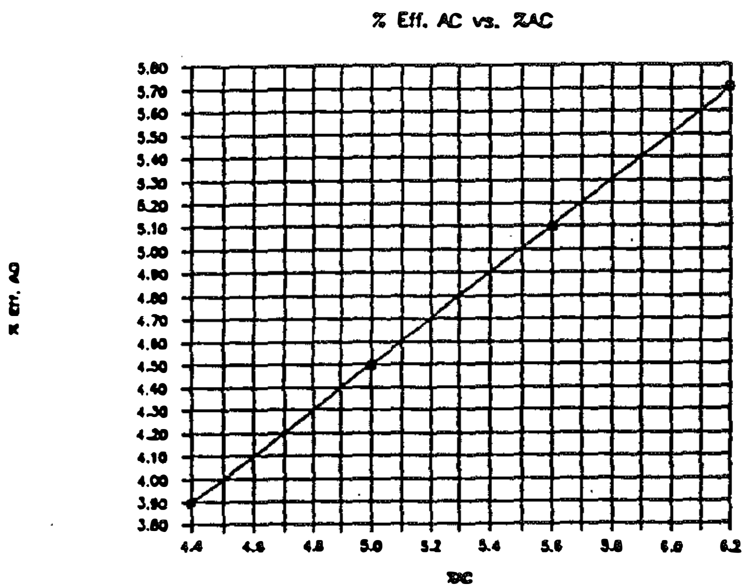
Asphalt Content, %	5.1
Voids in Mix, %	4.3
Max. Sp. Gravity	2.476
% VMA	14.8

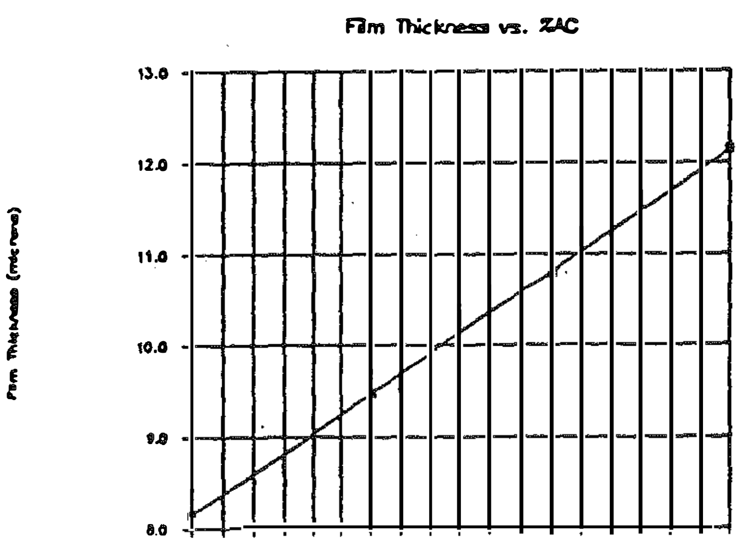
Remarks:

Although the percentage of voids in-mineral aggregate (% VMA is slightly low, the value is in reasonably close conforma with the specifications.

Mix Identification: # 14, Franklin Class AK Surface (Exp.)







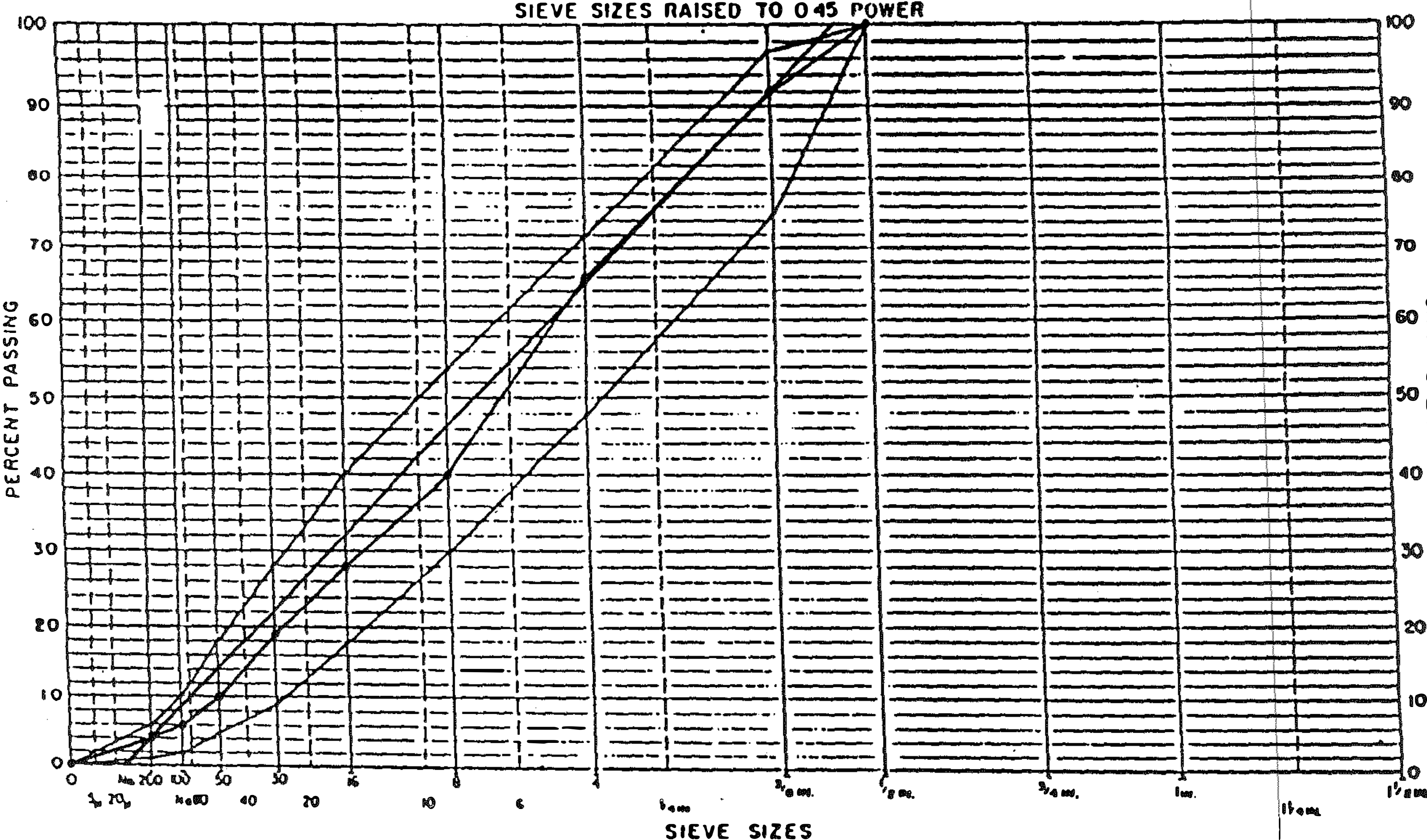
<u>Design Results</u>

Asphalt Content, %	5.1
% VFWA	72
% Eff. A.C.	4.6
Film Thickness	9.5

<u>Remarks:</u>

··· ··· ··· 003-005 014H (#211) @ Frankfort CLASS AK SURFACE (Exp

UNITED STATES BUREAU OF PUBLIC ROADS 0.45 POWER GRADATION CHART



A THIS SYMBOL IDENTIFIES SIMPLIFIED PRACTICE AND COMPATIBLE SIEVE SIZES	Identification of gradation: WET SIEVE	Sheet No. Date 2-24-93

Form No. OC-3

THE ASPHALT INSTITUTE

Fax Transmittal Memo 7672

To R.S. Quire		From K.C. Mahboub	122
Company H. Mays		Company UK	
Location		Location	Dept. Charge
Fax #	Telephone #	Fax #	Telephone #
Comments		Original Disposition: ☐ Destroy ☐ Return ☐ Call for pickup	

No. of Pages 1 Today's Date 7-9-93 Time 10:10 am

TRANSPORTATION CABINET
DIVISION OF MATERIALS

Rev. 2-88

C64-404 (12-A)

CONTRACTORS JOB-MIX FORMULA & ASPHALT PLANT ~~(BATCH)~~ DRUM MIX DESIGN

I.D. No. 009308539

INSPECTOR SSN	402-98-0902	County	Franklin
DATE SAMPLED	06-28-93	Name	R.Scott Quire — Crew Contractor
TYPE OF INSPECTION	INF	Sample Sequence No.	
PRODUCER NO.	PLB2001	Original Ident	
		Name	Frankfort Materials — Loc Frankfort
MATERIAL CODE	050125	Description	Class AK Surface (Exp.)
INSPECTED QUANTITY	9999999.9	Units	Tons
RESPONSIBLE LOC	05 — LAB 005	Name	
Detail Test	☐ — Distribution		

Proj Code	Project Number	QUANTITY	DATE ASSIGNED
022236	SSP 037 0421 003-005 074H	00000000.0	

DATE REC. ____ DATE COM. ____ PASS/FAIL ____ Reason ____

	Aggregate Prod. CD	Prod. Name	Mat'l. CD	Size	Aggregate %
Coarse	P002302	Nugent Sand & Gravel	001008	Gravel #8	42.0
Coarse					.
Fine	P002302	Nugent Sand & Gravel	001CKG5	Gravel mfg. sand	16.0
Fine	P002302	Nugent Sand & Gravel	001BFA	Natural Sand	19.0
Filler	P005101	Harrod Stone	001BFA	Limestone Sand	23.0

Screens-Scalper

Extractions Mix Gradations

Sieve Size	Job-Mix					Rev JMF	JMF/Specs
1/2	100						
3/8	92						
4	66						
8	40						
16	28						
30	18						
50	10						
100	6						
200	4.5						
F.M.							

Mix Approval Data		Plant Data	
Approved Asph Cont 5.3 %	Aggr/Batch ____ Lbs	Asph/Batch (Lbs.) ____	
Target Mix Temp 300	Total Batch Wt ____ Lbs	Gals of Asph/Batch (Fluidometer) ____	
Mix Time (Dry) ____ (Wet) ____			

Approved by DME ____ Date ____

Approved by MTL ____ Date ____

AK Surface w/ Rubberized A Approved by K. Mahboub (UK Research) at 5.3% / 5.5%. After tons of production on 1st day the %AC was revised to 5.1% by Danny on 7/13

% Bin 4 ___.__ Bin 3 ___.__ Bin 2 ___.__ Bin 1 ___.__ Filler ___.__ Totals ______

Pounds ______ ______ ______ ______ ______ ______

AccWt ______ ______ ______ ______ ______ ______

Cold Feed Data Non Polishing Agg(s) A.M. [ ] Coarse [ ] Fine (N.S.) P.M. [ ] Coarse [ ] Fine (N.S.)

Type Additive Rouse GF-80 123 crumb rubber

Asphalt Data

Type AC-20 030102 Producer Ashland @ Louisville P150901 Bitumen (By Design) 5.3 % Additive 7.5

Extraction Tests [ ].[ ] [ ].[ ] [ ].[ ] [ ].[ ]

Submitted By R. Scott Quire

Project Engineer [signature] 7-9-93 (UK.

Set up by Tech. ______

Date 6-29-93 MTLS Rep. ______

Plant Inspector ______

Remarks:

Copies:

M E M O R A N D U M

TO: BERNIE ROACH, P.E.,
D-5 MATERIALS ENGINEER

FROM: C. T. SMITH, C. T. Smith
RESIDENT ENGINEER C-312

DATE: AUGUST 11, 1993

SUBJECT: FRANKLIN COUNTY
SSP 037-0421-003-005
CONTROL STRIP RESULTS

PLEASE FIND ATTACHED THREE CONTROL STRIP FORMS TC63-49 FOR 7/13/93 & 7/16/93 CONCERNING AK SURFACE PLACED ON THE ABOVE SUBJECT PROJECT. ON JULY 13, 1993, TWO CONTROL STRIPS WERE CREATED TO ACCOMMODATE THE CHANGE IN ASPHALT CONTENT IN THE EXPERIMENTAL RUBBERIZED MODIFIED MIX. AS ONE CAN SEE THE IN PLACE DENSITIES FELL WELL WITHIN THE TARGET VALUES.

ATTACHMENTS

PC: D. WALKER, C.O. MATERIALS
K. C. MAHBOUB, U.K. RESEARCH

TC 63-49
Rev. 6/92

KENTUCKY TRANSPORTATION CABINET
Department of Highways
Division of Construction

In-place Density Using Control Strip

DIST. NO: 05

DATE: 12-13-93

METER NO:

MODEL NO:

PROJECT NO: SSP 037-0421-003-005

COUNTY: FRANKLIN

TYPE MAT'L: AK SURFACE (RUBBERIZED)

CONTRACTOR: H.G. MAYS CORPORATION

ROAD NAME: THORNHILL BY-PASS

ROUTE NO: (5.3)

ROLLERS

BRAND A: INGERSOLL RAND DESC: 2 WHEEL VIBRATORY WGT: 10-12 TON

BRAND B: INGERSOLL RAND DESC: 2 WHEEL VIBRATORY WGT: 8-10 TON

BRAND C: DESC: WGT:

REMARKS: PATTERN: 1 VIBRATORY & 3 FLAT PASSES WITH A AND 4 FLAT PASSESS WITH B

CONTROL STRIP

STA: 3+00 TO STA: 8+00 LENGTH: 500 FT: WIDTH: 12 FT.

REMARKS: SOUTH BOUND LANE: PASSING

3 DENSITY MEASUREMENTS

SITE 1 @ STA: 3+00 GEN. DESC: 3' RT CURB

SITE 2 @ STA: 6+00 GEN. DESC: 6' RT CURB

SITE 3 @ STA: 7+75 GEN. DESC: 6' RT CURB

DENSITIES:	TEST NO. 1		TEST NO. 2		TEST NO. 3		TEST NO. 4	COMMENTS
SITE 1:	131.6	lb/cf	139.3	lb/cf	138.7	lb/cf	138.7	
SITE 2:	135.7	lb/cf	140.4	lb/cf	141.5	lb/cf	140.9	
SITE 3:	139.1	lb/cf	140.9	lb/cf	143.2	lb/cf	144.7	
AVG:		lb/cf		lb/cf		lb/cf		

REMARKS:

TARGET DENSITY

RANDUM LOCATIONS	FIELD DENSITY		CORE DENSITY		COMMENTS
NO. 1 @ STA. 3+00	139.5	lb/cf	143.7	lb/cf	(SEE ROLLERS)
NO. 2 @ STA. 5+00	141.8	lb/cf	146.3	lb/cf	141.8/154.4= 92.0%
NO. 3 @ STA. 6+00	142.1	lb/cf	145.8	lb/cf	145.1/154.4= 93.97%
NO. 4 @ STA. 6+75	140.9	lb/cf	144.7	lb/cf	
NO. 5 @ STA. 7+75	144.7	lb/cf		lb/cf	**ADJUSTED TARGET DENSITY = lb/cf**
AVG DENSITY:	141.8	lb/cf	145.1	lb/cf	

REMARKS: STATIONS FOR CORES BASED ON EQ EXTENDING SOUTHERNLY STA. 0+00 = M.P. 4.820

Procedures in accordance with KM 64-432-92

INSPECTOR: [signature]

KENTUCKY TRANSPORTATION CABINET
Department of Highways
Division of Construction

TC 63-49
Rev. 6/92

DIST. NO: 05

DATE: 12613/93

METER NO: 620

In-place Density Using Control Strip

MODEL NO: ____

PROJECT NO: SSP 037-0421-003-005 COUNTY: FRANKLIN TYPE MAT'L: AK SURFACE (RUBBERIZED)

CONTRACTOR: H. G. MAYS CORPORATION ROAD NAME: THORNHILL BY-PASS ROUTE NO: 5.1

ROLLERS

BRAND A: INGERSOLL RAND DESC: 2 WHEEL VIBRATORY WGT: 10-12 TON

BRAND B: INGERSOLL RAND DESC: 2 WHEEL VIBRATORY WGT: 8-10 TON

BRAND C: ____ DESC: ____ WGT: ____

REMARKS: PATTERN: 1 VIBRATORY AND 3 FLAT PASSES WITH A AND 4 FLAT PASSES WITH B

CONTROL STRIP

STA: 3+00 TO STA: 8+00 LENGTH: 500' FT: WIDTH: 12 FT.

REMARKS: SOUTH BOUND LANE: DRIVING

3 DENSITY MEASUREMENTS

SITE 1 @ STA: 3+00 GEN. DESC: 18' RT CURB

SITE 2 @ STA: 6+00 GEN. DESC: 16' RT CURB

SITE 3 @ STA: 7+50 GEN. DESC: 20' RT CURB

DENSITIES:	TEST NO. 1		TEST NO. 2		TEST NO. 3		TEST NO. 4. COMMENTS
SITE 1:	133.2	lb/cf	136.5	lb/cf	138.3	lb/cf	137.2
SITE 2:	137.3	lb/cf	139.6	lb/cf	140.3	lb/cf	140.5
SITE 3:	142.7	lb/cf	142.3	lb/cf	141.5	lb/cf	141.5
AVG:		lb/cf		lb/cf		lb/cf	

REMARKS:

TARGET DENSITY

RANDUM LOCATIONS		FIELD DENSITY		CORE DENSITY		COMMENTS
NO. 1 @ STA.	3+00	139.0	lb/cf	142.6	lb/cf	(SEE ROLLERS)
NO. 2 @ STA.	5+00	138.3	lb/cf	142.2	lb/cf	
NO. 3 @ STA.	6+00	140.1	lb/cf	143.7	lb/cf	140.6/154.9=91.0%
NO. 4 @ STA.	6+75	143.3	lb/cf	144.7	lb/cf	143.3/154.9=92.5%
NO. 5 @ STA.	7+50	142.2	lb/cf		lb/cf	**ADJUSTED TARGET DENSITY = lb/cf**
AVG DENSITY:		140.6	lb/cf		lb/cf	

REMARKS: STATION FOR CORES BASED ON EQ EXTENDING SOUTHERNLY STA. 0+00 = M.P. 4.820

Procedures in accordance with KM 64-432-92

INSPECTOR: RB Wallace

TC 63-49
Rev. 6/92

KENTUCKY TRANSPORTATION CABINET
Department of Highways
Division of Construction

DIST. NO: 05

DATE: 127-16-93

METER NO: 620

In-place Density Using Control Strip

MODEL NO:

PROJECT NO: SSP 037-0421-003-005 COUNTY: Franklin TYPE MAT'L: AK Surface

CONTRACTOR: H. G. Mays Corporation ROAD NAME: Thornhill By-Pass ROUTE NO: U.S. 421

ROLLERS

BRAND A: Ingersoll-Rand	DESC: 2 Wheel Vibratory	WGT: 10-12 TONS
BRAND B: Ingersoll-Rand	DESC: 2 Wheet Vibratory	WGT: 8-10 TONS
BRAND C:	DESC:	WGT:

REMARKS:

CONTROL STRIP

STA: 0+00 TO STA: 5+30 LENGTH: 530 FT: WIDTH: 25 FT.

REMARKS: Off Ramp U.S. 421 LANE:

3 DENSITY MEASUREMENTS

SITE 1 @ STA: 0+00	GEN. DESC: OFF RAMP U.S. 421
SITE 2 @ STA: 0+80	GEN. DESC: OFF RAMP U.S. 421
SITE 3 @ STA: 2+30	GEN. DESC: OFF RAMP U.S. 421

DENSITIES:	TEST NO. 1	TEST NO. 2	TEST NO. 3	COMMENTS
SITE 1:	130.2 lb/cf	140.1 lb/cf	142.2 lb/cf	USED BELOW ROLLING PATTERN UNTIL
SITE 2:	138.1 lb/cf	139.9 lb/cf	141.5 lb/cf	DENSITIES BROKE OVER
SITE 3:	138.5 lb/cf	141.1 lb/cf	142.0 lb/cf	
AVG:	138.2 lb/cf	lb/cf	lb/cf	

REMARKS:

TARGET DENSITY

RANDUM LOCATIONS	FIELD DENSITY	CORE DENSITY	COMMENTS
NO. 1 @ STA. 0+00	141.7 lb/cf	146.3 lb/cf	ROLLING PATERN:
NO. 2 @ STA. 1+00	142.4 lb/cf	146.3 lb/cf	1 VIBRATORY PASS 3 FLAT PASSES(10-
NO. 3 @ STA. 2+00	142.9 lb/cf	146.4 lb/cf	4 FLAT PASSES(8-10 TON ROLLER)
NO. 4 @ STA. 3+00	140.5 lb/cf	142.9 lb/cf	141.7/154.9=91.5% 145.3/154.9=93.8
NO. 5 @ STA. 4+00	141.2 lb/cf	144.8 lb/cf	**ADJUSTED TARGET DENSITY = lb/cf**
AVG DENSITY:	141.7 lb/cf	145.3 lb/cf	

REMARKS:

Procedures in accordance with KM 64-432-92

INSPECTOR: RBWilley

APPENDIX C - Double Layer SAMI Guidelines

Recommended Guidelines for Application of a Double Seal Coat Using Crumb Rubber Modified A phalt Technology - A Membrane Application

Project Specific Notes

Location: Bridge Approach, Mason County, Maysville Bridge.
Subgrade: Low CBR (approximately 2).
Other: Use crumb rubber modified asphalt for construction of a double seal coat membrane on top of the subgrade.

Recommended Construction Sequence and Materials Specifications

1. Subgrade compaction at or 2% below the optimum moisture content and tapered along the shoulders for drainage.

2. No prime coat application on the compacted subgrade.

3. Seal coat applications should include all taper areas (shoulder, etc.).

4. First seal coat application:

   a. Rapid set cationic emulsion, preferably CRS-2.
   b. Rubber modified asphalt in the emulsion with 30%-35% water.
   c. Rich spray rate of emulsion, 0.3-0.4 gallon per squared yard.
   d. Cover the emulsion surface immediately after the spray with clean #57 stone with 40%-50% surface coverage.
   e. After application of the #57 stone, cover the surface with the rubber chips. These particles (0.25-0.5 inch) shall fill the voids left on the surface of the emulsion after the #57 application.
   f. Compaction with static steel drum roller (5-7 tons). One pass, one direction coverage only. When rollers are 48-54 inches wide, three rollers in tandem, with a slight overlap, may be necessary to cover the entire echelon.

4. Second seal coat application:

   a. Rapid set cationic emulsion, preferably CRS-2.
   b. Rubber modified asphalt in the emulsion with 30%-35% water.
   c. Rich spray rate of emulsion, 0.3-0.4 gallon per squared yard.

d. Cover the emulsion surface immediately after the spray with clean #9-M or #8, or #11 stone with at least 80% surface coverage.

e. Compaction with static steel drum roller (5-7 tons). One pass, one direction coverage only. When rollers are 48-54 inches wide, three rollers in tandem, with a slight overlap, may be necessary to cover the entire echelon.

Special Notes

1. There should be no duplicate handling of the emulsion. The emulsion should be delivered from the transport tank to the distributer tank as needed.

2. Pavement thickness design should not include a structural value for the double seal layer.

3. Pavement edge drains are recommended.

4. Subgrade instrumentation for temperature and moisture is highly recommended. This type of instrumentation will provide scientific data for reasons behind the success or failure of this project.

5. Use of Special Provision No. 99(91) dealing with partnering is highly recommended.